California Marine Life Protection Act Initiative

Draft Methods Used to Evaluate Marine Protected Area Proposals in the MLPA South Coast Study Region

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Executive Summary

This document provides the guidelines for design and methods used to evaluate alternative marine protected area (MPA) proposals for the California Marine Life Protection Act (MLPA) South Coast Study Region (SCSR). The MPA proposals are being developed through California's MLPA Initiative, a public/private partnership designed to assist the State of California in implementing the MLPA [California Fish and Game Code, Section 2853]. Developing and evaluating alternative MPA proposals is one component of an iterative process designed to "reexamine and redesign California's MPA system to increase its coherence and its effectiveness at protecting the state's marine life habitat, and ecosystems", as mandated by the MLPA.

The MLPA South Coast Regional Stakeholder Group (SCRSG) creates alternative MPA designs that integrate a variety of scientific and personal knowledge. The California Fish and Game Commission, the lead decision-making authority under the MLPA, has requested that the SCRSG not consider changes to the boundaries and regulations of the existing northern Channel Islands and Santa Barbara Island MPAs, but that these existing MPAs (using current boundaries, regulations and classifications) be included within, and evaluated as part of, the alternative MPA proposals developed for the SCSR.

Evaluations of alternative MPA proposals are conducted relative to the MLPA goals (Table 1-1 in Chapter 1), scientific guidelines described in the *California Marine Life Protection Act Master Plan for Marine Protected Areas* (hereafter called the *Master Plan*) and developed by the MLPA Master Plan Science Advisory Team (SAT), California Department of Fish and Game (DFG) feasibility criteria and California Department of Parks and Recreation guidelines. Potential impacts to commercial and recreational consumptive users also are evaluated. Evaluations are conducted by the SAT, MLPA Initiative staff, and contractors to the MLPA Initiative.

In addition to the guidelines for MPA design and associated evaluation methods, a discussion of the analysis and identification of bioregions in the SCSR are also included in this document. Bioregions are areas of the ocean where due to specific conditions such as ocean circulation and habitat, distinct species assemblages and communities occur. The consideration of bioregions in the design and evaluation of a network of MPAs is critical in ensuring that adequate representation of marine communities are included in MPAs.

Evaluations conducted by the SAT to address the scientific guidelines in the *Master Plan* include levels of protection, habitat representation and replication, size, and spacing. Additional analyses conducted by the SAT include birds and mammals, bio-economic modeling, and water quality. MLPA staff evaluate recreational, education and study opportunities while an MLPA contractor, Ecotrust, conducts an analysis of potential commercial and recreational fishery impacts.

The California Department of Fish and Game (DFG) conducts a feasibility analysis where alternative MPA proposals are evaluated against a set of feasibility criteria developed by DFG. The California Department of Parks and Recreation (State Parks) conducts an analysis where alternative MPA proposals are evaluated against a set of guidelines for MPA proposals developed by State Parks.

Bioregions

To help ensure that MPAs established under the MLPA include adequate representation of the marine communities and species diversity representative of California, MPAs must be distributed across biogeographically distinct areas. Both the MLPA and the *Master Plan* identify two biogeographic regions: 1) Point Conception north to the California-Oregon border and 2) Point Conception south to the U.S.-Mexico border (which includes the entire SCSR).

The SCSR refers to state waters off the mainland coast extending from Point Conception to the U.S.-Mexico border, and state waters surrounding all eight Channel Islands in the Southern California Bight. Southern California is characterized by strong gradients in environmental conditions (e.g., water temperature) and species abundances across the study region. Some parts of the study region (e.g., the western Channel Islands) contain biotic assemblages highly similar to central California, while others support quite different species communities that resemble those found in Mexican waters to the south. As has been done in previous study regions, the SAT conducted analyses to identify biogeographically relevant subregions (hereafter referred to as “bioregions”) within the large-scale biogeographic region to help ensure that distinct species assemblages within the study region are adequately represented in MPAs.

The SAT identified five bioregions that characterize the MLPA South Coast Study Region:

- North Mainland (Point Conception to Marina Del Rey)
- South Mainland (Marina Del Rey to U.S.-Mexico border)
- West Channel Islands (San Miguel, Santa Rosa and San Nicolas islands)
- Mid-Channel Islands (Santa Cruz, Anacapa and Santa Barbara islands)
- East Channel Islands (Santa Catalina and San Clemente islands)

The SAT recommends including representation of all key habitats in each bioregion (see habitat representation). Representation of key habitats in each of the five bioregions of the SCSR will be considered as part of the habitat representation evaluation for alternative MPA proposals. Replication of habitats will also be evaluated for each bioregion and the entire SCSR.

Levels of Protection

Types of activities that may be allowed within the three types of marine protected areas (state marine conservation area, state marine park, and state marine reserve) differ in the level of protection they provide to marine ecosystems. To facilitate comparison across alternative MPA proposals, the SAT assigns a “level of protection” to each MPA based on the uses allowed within its boundaries.

Levels of protection are based upon the likely impacts of proposed activities to the ecosystems within a MPA. Conceptually, the SAT seeks to answer the following question in assigning levels of protection: “How much will an ecosystem differ from an unfished ecosystem if one or more proposed activities are allowed?”

State marine reserves (SMRs) are, by definition, unfished ecosystems, therefore they receive the highest protection level, “very high”. MPAs that allow extractive activities receive levels of protection ranging from “high” for low-impact activities, to “low” for activities that alter habitat and thus are likely to have a large impact on the ecosystem. Both direct impacts (those resulting directly from the gear used or removal of target or non-target species) and indirect impacts (ecosystem-level effects of species removal) are considered in the levels of protection analysis. Table 1 summarizes levels of protection assigned to various targeted species and gear types. As the need arises, the SAT will evaluate additional targeted species and gear types.

Table ES-1. Level of protection and the activities associated with levels of protection in the MLPA South Coast Study Region

	Level of Protection	MPA Type	Activities Associated with a Protection Level
	Very high	SMR	No take
	High	SMCA	Coastal pelagic finfish, bonito, and market squid (pelagic seine, dip-net, crowder); jumbo squid (squid jigs); swordfish (harpoon); **In water depth > 50m:** pelagic finfish, bonito and white seabass (H&L; spear at any depth)
	Moderate-high	SMCA	Catch and release in <10m water or using surface gear (H&L single barbless hooks and artificial lures only); pier-based fishing (H&L, hoop-net); halibut (spear); **In water depth 30<50m <u>on mainland</u>:** pelagic finfish, bonito and white seabass (H&L)
	Moderate	SMCA SMP	spot prawn (trap/pots); sea cucumber (scuba/hookah); grunion (hand harvest); giant kelp (hand harvest); clams (hand harvest)
	Moderate-low	SMCA SMP	Catch and release in >10m (H&L); shore-based finfish (H&L); kelp bass, barred sand bass, lingcod, cabezon, and rockfish (H&L, spear); sheephead (H&L, spear, trap); spotted sand bass and halibut (H&L); lobster (trap, hoop net, scuba); urchin (scuba/hookah); rock crab and Kellet's whelk (trap); **In water depth <50m at islands and <30m on mainland:** pelagic finfish, bonito and white seabass (H&L)
	Low	SMCA SMP	rock scallop (scuba); mussels (hand harvest); giant kelp (mechanical harvest); marine algae other than giant and bull kelp (hand harvest)

H&L = hook and line. The SAT is currently reviewing the level of protection for numerous activities, this table will be updated as activities are reviewed and approved by the SAT. It should be noted that staff is working with the SAT to coordinate terminology for particular gear types that is consistent with both the activities being proposed by the RSG and as defined in regulations under California Fish and Game Code. Thus the descriptions here may change in a future version of this document.

The level of protection assigned to an MPA that allows multiple uses is the lowest level of protection designated for any of the uses. The SAT's "level of protection" analysis does not currently account for the cumulative impacts of multiple activities within a single MPA, but the SAT is working to address this issue.

The levels of protection assigned by the SAT are used in all subsequent SAT analyses. Only MPAs at the three highest levels of protection, "moderate-high," "high," and "very high," contribute toward replication and are considered as part of the size and spacing analysis.

Habitat Representation

The SAT recommended that "For an objective of protecting the diversity of species that live in different habitats and those that move among different habitats over their lifetime, every "key" marine habitat should be represented in the MPA network[1]." California's key marine habitats are described in the MLPA and have been further subdivided by the SAT to reflect important ecological differences at different depths. This habitat classification yields a total of 22 key habitats for which habitat representation is assessed contingent upon habitat map quality: rocky shore, sandy beach, surfgrass, coastal marsh, tidal flats, estuarine waters, eelgrass, kelp, hard and soft substrates in four depth zones (0-30 meters, 30-100 meters, 100-200 meters, and greater than 200 meters), submarine canyons, pinnacles, upwelling centers, retention zones, river plumes, and oceanographic fronts.

In evaluating habitat representation the SAT considers:

- The availability of habitats across the entire SCSR
- The availability of habitats within the five bioregions of the SCSR
- The percentage of available habitat protected in MPAs across six levels of protection
- The distribution of habitat protection across the five bioregions

The SAT also identified unique habitats in southern California, including oil seeps (concentrated in the Santa Barbara Channel) and shallow hydrothermal vents (off White Point on the Palos Verdes Peninsula). The unique habitats will be noted if they occur within an alternative MPA proposal but no minimum size threshold will be estimated for unique habitats and they will not be evaluated for habitat representation or replication.

Habitat Replication

Habitat replication within broad biogeographic regions is required by the *Master Plan*. The *Master Plan* identifies just two biogeographic regions in California: 1) Point Conception north to the California-Oregon border and 2) Point Conception south to the U.S.-Mexico border. The SAT recommended three to five replicates of each key habitat type within marine reserves in each biogeographic region. The entire SCSR lies within a single biogeographic region so the guideline for replication should be applied at this scale. Considering the strong physical and

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[1]*California Marine Life Protection Act Master Plan for Marine Protected Areas*

biological gradients across the SCSR, the SAT has additionally recommended at least one replicate of each key habitat be included in each of the five bioregions of the SCSR.

To count as a replicate of any given habitat, a MPA must contain enough habitat to encompass 90% of the biodiversity associated with that habitat. The minimum area to encompass 90% of the associated biodiversity varies by habitat and is determined from biological surveys. A summary of the minimum areas for replicates of key habitats in the SCSR is in Chapter 5 (and in Table ES-2.).

Table ES-2. Amount of habitat in an MPA necessary to encompass 90% of local biodiversity given in linear statute miles and square statute miles.

Habitat	Representation needed to encompass 90% of biodiversity	Data Source
Rocky Intertidal	~0.48 linear miles	PISCO Biodiversity
Shallow Rocky Reefs/Kelp Forests (0-30 m)	~1.14 linear miles	CRANE Subtidal Surveys
Deep Rocky Reefs (30-100 m)	~0.20 square miles	Love Surveys
Deep Rocky Reefs (100-3000 m)	~0.22 square miles	Love Surveys
Sandy Beaches[1]	~1.14 linear miles	See below
Soft Bottom Habitat (0-30 m)	~1.14 linear miles	See below
Soft Bottom Habitat (30-100 m)	~2.24 square miles	SCCWRP (BIGHT '98 & '03)
Soft Bottom Habitat (100-200 m)	~1.10 square miles	SCCWRP (BIGHT '98 & '03)
Soft Bottom Habitat (>200 m)	~0.46 square miles	SCCWRP (BIGHT '98 & '03)
All Soft Bottom Habitat (>0 meters)	***~8 square miles***	***Preferred option - see Chapter 5***
Estuarine Habitats	0.12 square miles (77 acres)	SONGS sampling

[1] Sandy beaches are often linked to shallow soft bottom areas, therefore linear extent for sandy beaches is tied to linear extent of soft bottom habitat, see below for further explanation.

In order for estuarine habitats to be considered present, a minimum of 77 acres of estuarine habitats must be included within an MPA. For the three sub-habitats eelgrass, tidal flats, and coastal marsh to be considered present, a minimum of 25 acres of each must be included within an MPA. The SAT recommends that wherever possible, a mixture of estuarine sub-habitats be protected in close proximity to one another to allow for the movement of species among sub-habitats.

In evaluating replication of key habitats, the SAT:

- combines contiguous MPAs at or above the three highest levels of protection into "MPA clusters." Replication analyses are conducted at three different levels of protection: "moderate-high," "high," and "very high" and include all MPAs at or above the stated level of protection.
- considers whether there is a minimum amount of each key habitat present within an MPA cluster, and whether the MPA cluster meets the minimum size threshold, as described below.
- tabulates the number of replicate MPA clusters for each habitat within the biogeographic region (Point Conception to the U.S.-Mexico border) relative to the guideline of three to five replicates per biogeographic region tabulates the number of replicate MPA clusters for each habitat within each of the five bioregions (north and south mainland, and west, mid- and east Channel Islands) relative to SAT guidance to include at least one replicate of each habitat per bioregion.

MPA Size

The SAT recommended "For an objective of protecting adult populations, based on adult neighborhood sizes and movement patterns, MPAs should have an alongshore span of five to ten kilometers (3-6 miles) of coastline, and preferably 10-20 km (6-12.5 miles). Larger MPAs would be required to fully protect marine birds, mammals, and migratory fish[2]."

The SAT recommended that MPAs extend from intertidal to offshore areas for an objective of protecting the diversity of species that live at different depths and to accommodate the movement of individuals to and from shallow nursery or spawning grounds to adult habitats offshore. The recommended offshore span is from the mean high tide line to the offshore state waters boundary, generally a distance of 3.45 miles (3 nautical miles), except in some areas (e.g., offshore rocks) where state boundaries may extend further.

Taking into account these two guidelines, the SAT recommended a minimum area of 9 – 18 square miles for each MPA, and preferably 18 – 36 square miles. The recommendation of a minimum area of 9 square miles is a simplified combination of the along-shore and offshore size guidelines and allows for the possibility that the alongshore span may be less (or greater) than three miles or the offshore span may be less than 3.45 miles. The guidelines for minimum and preferred areas of proposed MPAs will receive priority above the individual guidelines for alongshore and offshore spans. Additionally, the SAT recommends consideration of the configuration of proposed MPAs. Configurations with maximum area-to-perimeter ratios (e.g.,

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[2] California Marine Life Protection Act Master Plan for Marine Protected Areas

3 x 3 statute miles) are more likely to achieve greater protection for a variety of adjacent habitats and associated species than narrow and long MPAs (e.g.,1 x 9 statute miles).

In evaluating the size of MPAs, the SAT:

- combines contiguous MPAs at or above the three highest levels of protection into “MPA clusters.” Size analyses are conducted at three different levels of protection: “moderate-high,” “high,” and “very high” and include all MPAs at or above the stated level of protection.
- tabulates the number of MPA clusters in each size range (below minimum, minimum size range, preferred size range).

MPAs containing estuarine habitat are not evaluated against the general rule that replication of habitat needs to be within an MPA cluster that is at least nine square miles.

MPA Spacing: Mainland Coast

The SAT recommended “For an objective of facilitating dispersal of important bottom-dwelling fish and invertebrate groups among MPAs, based on currently known scales of larval dispersal, MPAs should be placed within 50-100 km (31-62 miles) of each other” along the mainland coast of southern California. Neighboring MPAs placed closer than 50 km (31 miles) apart also meet the guideline for spacing for the goal of designing a network of MPAs.

In evaluating the spacing of MPAs for the mainland coast, the SAT:

- combines contiguous MPAs at or above the three highest levels of protection (“moderate-high,” “high,” and “very high”) into “MPA clusters” and include all MPAs at or above the stated level of protection.
- considers MPA clusters of sufficient size (minimum MPA cluster size of nine square miles), with sufficient amounts of key habitats included, and given at least a moderate-high level of protection.
- determines the distance between replicates of key habitats within MPAs relative to the minimum spacing guideline of 31-62 miles of one another along the mainland coast of southern California.
- estimates the distance between protected patches of the same key habitat.
- analyzes distances between neighboring MPAs separately for each key habitat.

MPA Spacing: Channel Islands

Connectivity between Channel Islands (and between islands and mainland) is influenced and limited by their complex geography and ocean circulation. A simple guideline for MPA spacing does not account for these complex variables. The SAT recommended that guidelines other than spacing should serve as a starting point for design of MPAs at the Channel Islands. Those guidelines include bioregions, habitat representation, habitat replication, and MPA size.

Modeling

Spatially-explicit bioeconomic models use data on habitat, fishery effort and proposed MPA locations and regulations to estimate biomass and larval supply (estimates of conservation value) and fishery yield and profits (estimates of economic impacts) for a suite of about 10 representative species. The modeling is an additional and complementary tool to other SAT evaluations.

Two models emerged from earlier efforts to apply modeling to evaluating alternative MPA proposals. A model developed by researchers at University of California, Davis (UCD model) considers each fished species separately, and focuses on sustainability of fished populations under each alternative MPA proposal, using current estimates of fishery stock status to help predict future management success. A model developed by scientists at the University of California, Santa Barbara (UCSB model), and based on previous work by members of the north central coast SAT[3], focuses on the tradeoffs between fisheries performance (profits) and fish abundance. Both models incorporate spatially explicit fishery regulations and predicted behavioral shifts of fishers in response to changes in the regulations (e.g., after MPAs are established).

Model outputs are not expressed in terms of minimum or maximum threshold values, so outputs from the evaluation of alternative MPA proposals must be compared to each other to understand the potential impacts of changes to the design. For the modeling evaluation of alternative MPA proposals, the SAT will provide:

- maps of biomass and larval supply[4] for a suite of about 10 representative species and a map that shows the weighted average biomass of all species
- figures that summarize the study region-wide effects of all MPA proposals on biomass and larval supply[5]
- maps of fishery yield and profits[6] of the suite of about 10 representative species and a map that shows the weighted average biomass of all species
- figures that summarize the study region-wide effects of all MPA proposals on fishery yield and profits[7]
- maps of spatial fishing intensity for the suite of about 10 representative species and a map that shows the weighted average of spatial fishing intensity for all species

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[3] The UCSB model adopts many of the key assumptions of the Equilibrium Delay Difference Optimization Model (EDOM), developed by C. Walters, R. Hilborn, and C. Costello in the North Central Coast Study Region.

[4] The UCD model estimates larval supply, in addition to biomass and fishery yield.

[5] The UCD model estimates larval supply, in addition to biomass and fishery yield.

[6] The UCSB model estimates fishery profits, in addition to biomass and fishery yield.

[7] The UCSB model estimates fishery profits, in addition to biomass and fishery yield.

- diagrams that illustrate the level of connectivity between different places in the SCSR for the suite of about 10 representative species
- figures that show tradeoffs between the conservation value (estimated as biomass and larval supply[8]) and economic return (estimated as fishery yield and profits[9])

Birds and Mammals

MPAs may benefit marine birds and mammals by protecting their forage base and by potentially reducing human disturbance to roosting and haul-out sites, and breeding colonies or rookeries. To evaluate the protection afforded by alternative MPA proposals to birds and mammals, the SAT:

- Identifies proposed MPAs or special closures that contribute to protection of birds and mammals.
- Identifies focal species likely to benefit from MPAs and for which data are available.
- Estimates the proportion (of total numbers of individuals) of breeding bird/mammal at colonies and rookeries potentially benefiting by proposed MPAs.
- Estimates the proportion of nearby foraging areas protected by MPAs, defined by evaluating protection of buffered areas around colonies.
- Estimates the number of neritic foraging ‘hot spots’ protected by MPAs, defined by at-sea densities of marine birds and mammals.
- Estimates the proportion of marine birds and mammals that inhabit estuaries and coastal beaches protected by MPAs.

Water Quality

While water quality is not subject to management under the MLPA, it may be important in designing alternative MPA proposals. Where water quality is significantly compromised, marine life may be affected. Impaired water quality may lead to changes to population rates (growth, reproduction, and mortality), population abundance and ecological community composition through a variety of interactions (e.g., decreased diversity, loss of sensitive species and abundance of tolerant species).

For MPA network design, the SAT recommends including areas already designated as areas of special biological significance (ASBSs) because these areas benefit from protection beyond that offered by standard waste discharge restrictions. The SAT recommends avoiding locations of poor or threatened water quality, including

- major cooling water intake sites for power plants
- municipal sewage or industrial outfalls

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[8] The UCD model estimates larval supply, in addition to biomass and fishery yield.

[9] The UCSB model estimates fishery profits, in addition to biomass and fishery yield.

- areas that are significantly impacted by a variety of pollutants from large industrial or developed watersheds

The SAT determined that MPAs may be placed in or near areas of impaired water quality (e.g. Santa Monica Bay) if there are other reasons to place MPAs in such areas.

Since water quality evaluations are not mandated by the MLPA, these guidelines based on consideration of water quality are secondary to other MPA network design guidelines. Other guidelines (including bioregions, habitat representation and replication, and MPA size and spacing) should be used to drive design of alternative MPA proposals. Water quality considerations may be incorporated if other guidelines have been met. The SAT has not yet completed a methodology for evaluating alternative MPA proposals. Details about the evaluation of MPA proposals for water quality will be updated pending SAT discussions and recommendations.

Recreational, Education and Study Opportunities (Goal 3)

MLPA Initiative staff evaluates the potential recreational, educational, and study opportunities provided by each MPA proposal in terms of the MPAs' overall accessibility, proximity to educational institutions, inclusion of existing monitoring sites, and consideration of replication in design.

In evaluating the alternative MPA proposals, MLPA Initiative staff considers:

- Access points within and near MPAs, including proximity to boat launches and ports. Proximity to MPAs that allow many uses versus MPAs that allow few uses may have different effects on different users.
- Inclusion of existing monitoring sites and close proximity to research institutions, which may increase study opportunities.
- Replication of habitats within MPAs, which may offer research opportunities.

Recreational and Commercial Fishery Impacts

While fishery impacts are not the focus of the MLPA, they are considered in designing an MPA network. The evaluation of maximum potential recreational and commercial fishery impacts utilizes region-specific data on areas of importance collected by MLPA contractor, Ecotrust.

To evaluate the potential recreational and commercial fishery impacts, MLPA Initiative staff and contractors:

- Conduct interviews with recreational and commercial fishermen, using an interactive, custom computer interface, to collect geo-referenced information about the extent and relative importance of study region commercial and recreational fisheries.
- Organize impact analyses by port, fishery and/or user group.

- Evaluate and summarize the maximum potential impacts[10] on commercial and recreational fishing grounds, both in terms of total area and value affected. Results are summarized for both study region fishing grounds and total fishing grounds.
- Conduct a socioeconomic impact analysis for commercial fisheries.
- Consider or identify "outliers" (i.e. fishermen likely to experience disproportional impacts).

Assess the effect of existing fishery management area closures and other constraints on fishing opportunities.

[10] Impact analyses represent a "worst case" scenario where fisherman cannot fish in a different location.

1. Overview

The California Marine Life Protection Act (MLPA) found that California's marine protected areas (MPAs) were established on a piecemeal basis and lacked sound scientific guidelines (California Fish and Game Code, Section 2851). The MLPA identifies two distinct biogeographic regions in California, one of which constitutes the MLPA South Coast Study Region (SCSR). The development and evaluation of draft MPA proposals is one component of an iterative process designed to "reexamine and redesign California's MPA system to increase its coherence and its effectiveness at protecting the state's marine life habitat and ecosystems," as mandated by the MLPA.

The MLPA South Coast Regional Stakeholder Group (SCRSG) will create alternative MPA proposals that integrate a variety of scientific and personal knowledge. In addition, outside parties may submit MPA proposals.

Evaluations of alternative MPA proposals are conducted relative to MLPA goals (Table 1-1), scientific guidelines provided in the *Master Plan* and developed by the SAT, feasibility criteria developed by the California Department of Fish and Game (DFG), and guidelines developed by the California Department of Parks and Recreation (State Parks). Potential impacts to commercial and recreational consumptive users also are evaluated. Evaluations are conducted by the SAT, MLPA Initiative staff, DFG, State Parks and contractors to the MLPA Initiative.

Table 1-1. MLPA Goals and Evaluation Elements Relating to Each Goal

MLPA Goal	Evaluation Elements
1. To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.	• Levels of protection • habitat representation • modeling • birds and mammals
2. To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.	• Levels of protection • MPA size and spacing • modeling • birds and mammals
3. To improve recreational, educational, and study opportunities provided by marine ecosystems that are subjected to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity.	• Habitat replication • (MPA and habitat size) • recreational, educational & study opportunities
4. To protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value.	• Levels of protection • habitat representation and replication

MLPA Goal	Evaluation Elements
5. To ensure that California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines.	• California Department of Fish and Game Feasibility Analysis • California Department of Fish and Game Goals and Objectives Analysis • California Department of Parks and Recreation
6. To ensure that the state's MPAs are designed and managed, to the extent possible, as a network.	• Size and spacing • (MPA and habitat size) • modeling

The California Fish and Game Commission has requested that the SCRSG not consider changes to the boundaries and regulations of the existing northern Channel Islands and Santa Barbara Island MPAs, but that these existing MPAs (using current boundaries, regulations and classifications) be included within, and evaluated by the SAT as part of, the alternative MPA proposals developed for the MLPA SCSR.

2. Bioregions

Status of this chapter: The SAT has approved of the bioregions presented in this chapter.

Summary of the Master Plan's Guidelines Regarding Bioregions

The MLPA indicates that MPAs should "encompass a representative variety of marine habitat types and communities, across a range of depths and environmental conditions." Pursuant to this recommendation the SAT has identified five biologically relevant subregions (bioregions) within the SCSR. Each of these five bioregions is characterized by a unique set environmental conditions and a distinct assemblage of marine organisms. Distribution of MPAs across all five bioregions will ensure that marine habitats and communities are protected across the full range of environmental conditions present in the South Coast Study Region.

Species abundances, species diversity, and the makeup of ecological communities vary across habitats (e.g. shallow rock reefs, deep rock reefs, sandy bottom), but also vary geographically within a habitat type along with changing environmental conditions. Thus, the biological community within a particular habitat or ecosystem, such as kelp forest, can differ markedly from one part of the coast to another. Geographic areas that contain substantially distinct species compositions are known as biogeographic or biogeographical regions. These biogeographical regions reflect collections of species that share similar geographic ranges that are largely limited to each region.

In order to help ensure that MPAs established under the MLPA capture adequate representation of the species communities and species diversity representative of California, MPAs must be distributed across biogeographically distinct areas. Both the MLPA and the *Master Plan* identify a single, large-scale "biogeographical region" that is identical to the MLPA South Coast Study Region, which extends from Point Conception to the U.S./Mexico border, including the eight Channel Islands in the Southern California Bight. Compared with previous study regions, the south coast study region is characterized by strong gradients in environmental conditions (e.g. water temperature) and species abundances across the study region. Some parts of the study region, such as the western Channel Islands, contain biotic assemblages highly similar to those of central California while others support quite different species communities resembling those found in Mexican waters to the south.

Bioregion Analysis

As in previous study regions, the SAT conducted analyses to identify biogeographically relevant subregions (hereafter referred to as bioregions) within the large-scale biogeographical region. This is to ensure that distinct species assemblages *within* the larger study region are adequately represented in MPAs proposed under the MLPA process. Distribution of MPAs across these small-scale bioregions will ensure that habitats are protected "across a range of environmental conditions" as stipulated in the act. In order to determine these bioregions, the SAT analyzed five sources of data across four habitat types and various taxonomic species groups, to develop a synthetic model that best defines existing spatial patterns of community variation. Not all data sets included sites distributed throughout the full extent of the Southern California Bight. These data sets and habitat types were:

- For deep (>30m) rocky reef habitat, Dr. Milton Love (unpublished data) described three geographic subregions of distinct fish assemblages in the Southern California Bight (Fig. 2-1).
- For deep (>30m) soft habitat, bottom trawl surveys conducted by the Southern California Coastal Water Research Project (SCCWRP, 2003) were used to describe geographic variation in benthic macroinvertebrate and fish assemblages. These data indicate three subregions of distinct fish assemblages in the south coast study region (Fig. 2-2).
- For shallow (<30m) rocky reef habitat, diver surveys conducted by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO, unpublished data) and the Cooperative Research and Assessment of Nearshore Ecosystems (CRANE, 2008) were used to describe patterns of geographic variation across the northern Channel Islands and bight-wide, respectively. PISCO surveys defined two subregions of distinct fish assemblages across the northern Channel Islands (Fig. 2-3) and four similar subregions of distinct invertebrate assemblages (Fig. 2-4). Crane surveys across the Southern California Bight identified four distinct subregions of fish and invertebrate assemblages (Fig. 2-5).
- For rocky intertidal habitats, surveys of community structure conducted by the Multi-Agency Rocky Intertidal Network (MARINe, unpublished data), showed five geographic subregions of distinct intertidal communities (Fig. 2-6).

Geographic distinctions between fish and algal assemblages were detected in three of these five datasets (PISCO and CRANE shallow subtidal and PISCO intertidal) using hierarchical cluster analysis (Primer ver. 6). Bray-Curtis similarity measures are first calculated between all pairs of survey sites by comparing abundances of individual species. Raw species counts were first square-root transformed to ensure sensitivity to both rare and super-abundant species. A group-average linkage technique was then used to find clusters among sites with the highest within-group similarity, and produce a hierarchical structure or dendrogram which shows how individual sites and site groups are related to one another. This method of cluster analysis is the most commonly used and widely accepted approach for this type of data (Clark and Warwick, 2001). Statistical significance of these cluster groupings was then tested using SIMPROF tests, a permutation technique which assigns probability values to each site or site group detected in the data. In all cluster analyses, differences between groups were evaluated at the 99% significance level, but in most cases some finer scale site groupings were subsequently combined into larger groupings by taking a slice through the dendrogram at a given level (e.g. 60%) of similarity.

These five datasets indicated very similar, but not identical, sets of bioregions between Point Conception and the California/Mexico border. To develop a synthesis, a number of models were tested against all these datasets to generate a single bioregional scheme that best reconciled the data contained in these five datasets. The best fit model suggested five bioregions across the south coast study region (Fig. 2-7).

For some species assemblages and regions for which data were not available in the data sets we analyzed, the literature was reviewed to determine if prior studies had identified patterns of regionally distinct species assemblages. For example, PISCO and CRANE surveys of shallow rocky reef fish assemblages were not conducted along the mainland coast of the Santa Barbara Channel. However, Ebeling et al. (1980) conducted extensive fish surveys in this region and a similar analysis of assemblage structure and found that the structure of shallow reef fish assemblages differed by 80% between the islands and mainland (Fig. 2-8). Similarly, Pondella and Allen (2000) compared shallow fish assemblages between Santa Catalina Island and sites along the southern California mainland and found distinctive assemblage structure between island and mainland sites. A broader bight-wide comparison of rocky reef fish assemblages on islands and mainland sites defined similar differences between island and mainland sites that were independent of distances between islands (Pondella et. al., 2005). Taken together, these studies reinforce the general conclusion that islands and the southern California mainland define separate bioregions.

One other key study that supports both the island-mainland contrasts and, more broadly, the five bioregions proposed from this analysis, is the biogeographic survey of rocky intertidal macrophyte communities conducted by Murray and Littler (1981) throughout the islands and mainland of the Southern California Bight. Previous studies cited from the literature as well as analyses conducted by the SAT indicate a close relationship between the distribution of distinct assemblage structures and large scale oceanographic patterns, such as currents and associated water temperatures.

The number and exact location of divisions between the geographic groupings varied across the five datasets; as a result, additional analyses were undertaken to assess how well the data correspond to the structure imposed by proposed bioregions in the best fit model. Both rocky intertidal and shallow rock reef community data showed significant differences among groups when sites were assigned a priori to the five proposed bioregions (ANOSIM, P=0.01) supporting our synthetic scheme (Fig. 2-7). Oceanographic and geologic conditions were not directly assessed in the process of determining bioregions, but the patterns of diversity and community structure generally reflect known oceanographic and geologic gradients in the Southern California Bight. Thus the SAT concludes that these five bioregions reflect real spatial patterns of biodiversity and community structure in the south coast study region. The differences in community are illustrated in figures 2-9 and 2-10.

Implications of Biogeographical Subregions on Habitat Representation and Replication

Because the analyses presented here indicate that each of the five bioregions in Figure 2-7 contain different species compositions and/or assemblages, it is recommended that key habitats from within each bioregion are represented in MPAs. As noted earlier, this is to ensure that both the different community assemblages and the ecosystem functioning representative of the MLPA South Coast Study Region are appropriately represented in the MPA network. For purposes of habitat representation this implies that, at a minimum, a single replicate of suitable size for each key habitat should be included in an MPA in each bioregion. In practice, however, it is expected that MPA proposals will include more than one MPA in each bioregion in order to meet SAT spacing guidelines.

Figure 2-1. Deep Rocky Reef Fish Assemblages

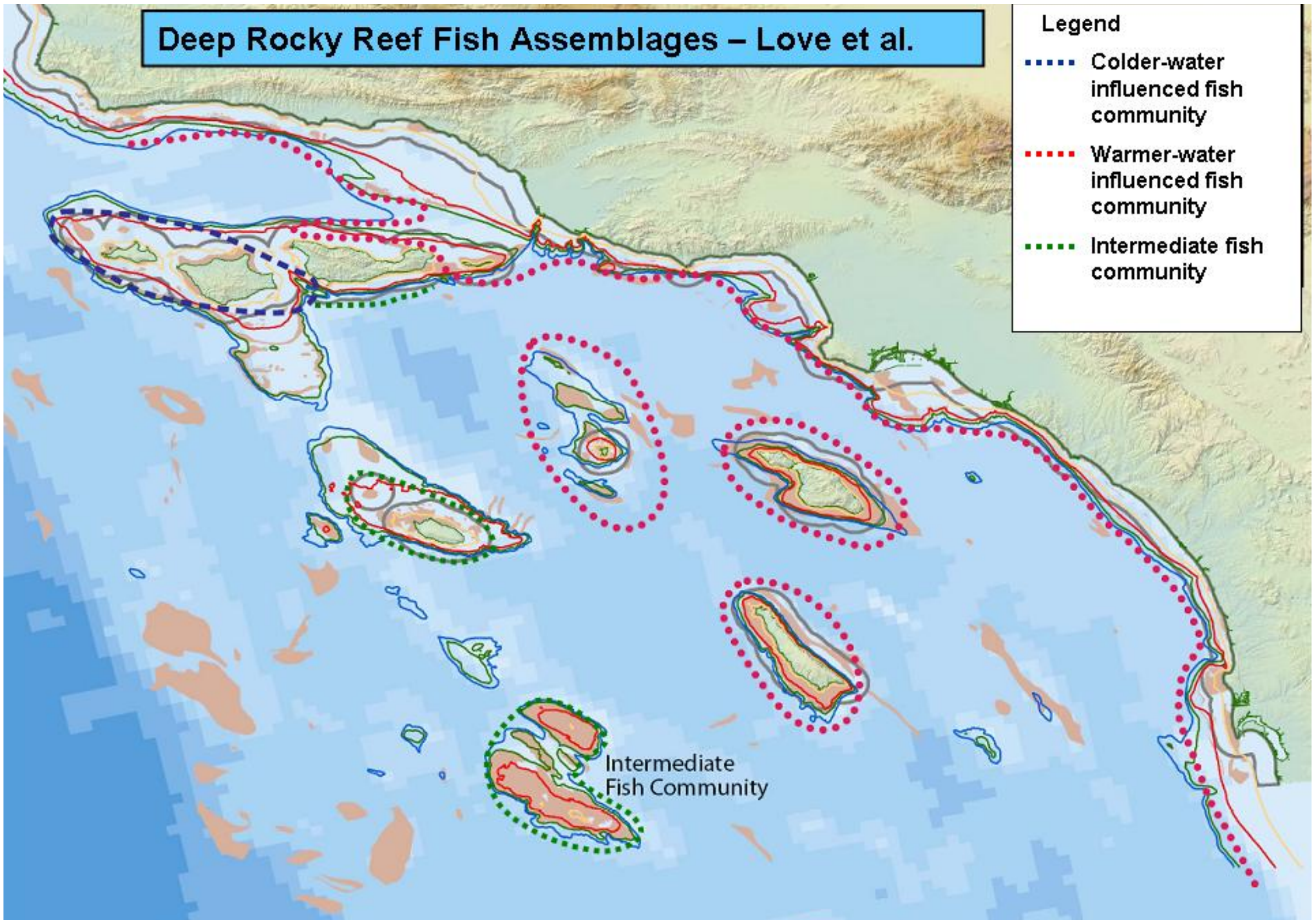
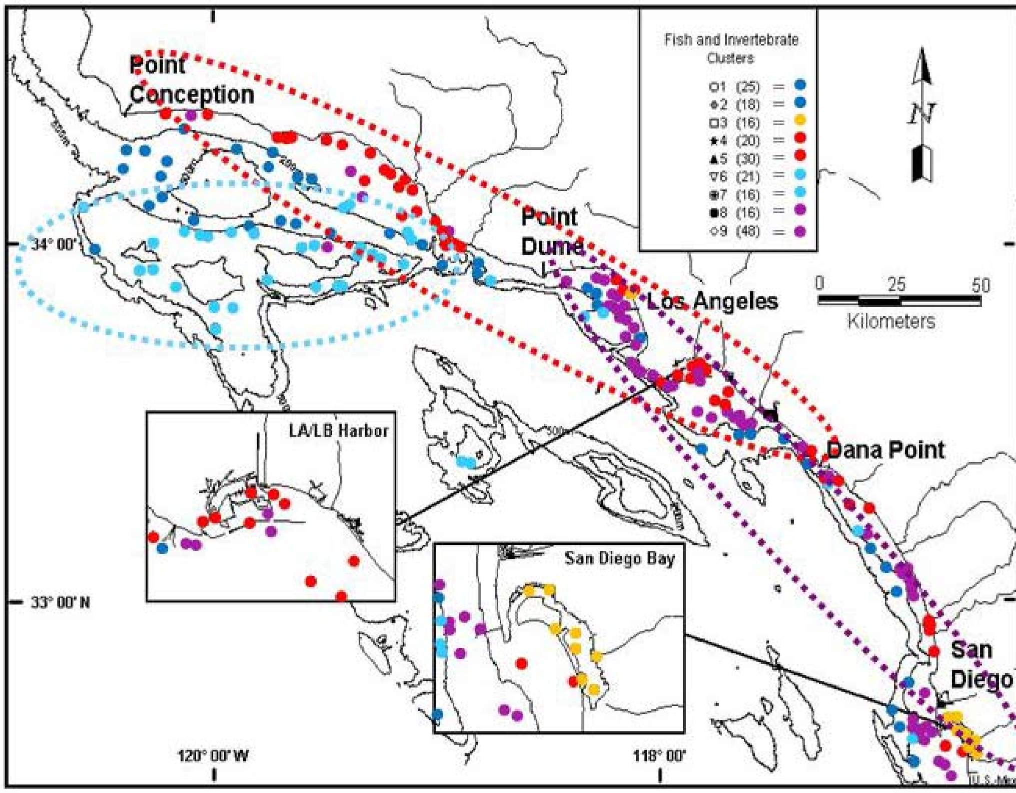


Figure 2-2. Distribution of Demersal Fish and Megabenthic Invertebrate Site Cluster

Distribution of demersal fish and megabenthic invertebrate site cluster on the southern California shelf and upper slope at depths of 2-476 m, July-October 2003.



SCCWRP 2003 Annual Report - Figure VI-14.

Figure 2-3. Fish Community Structure

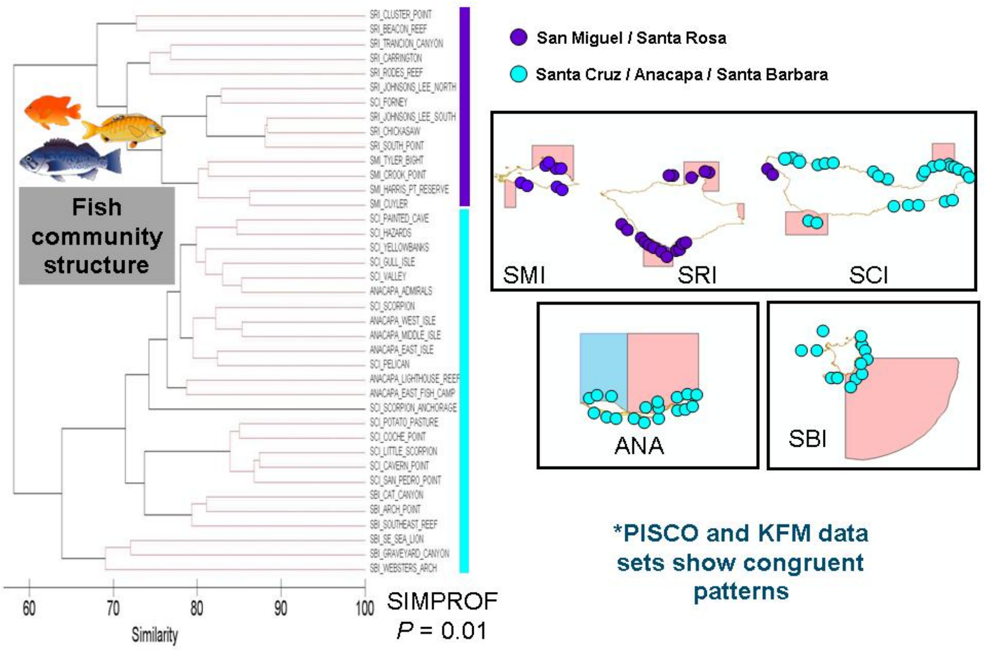


Figure 2-4. Invertebrate Community Structure

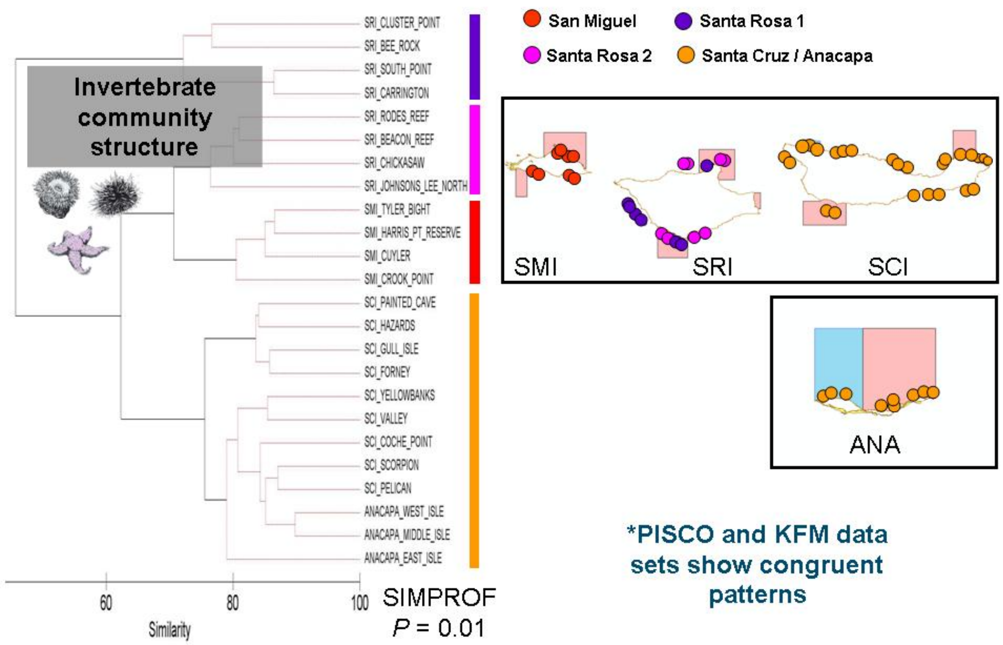


Figure 2-5. Shallow Rocky Reefs

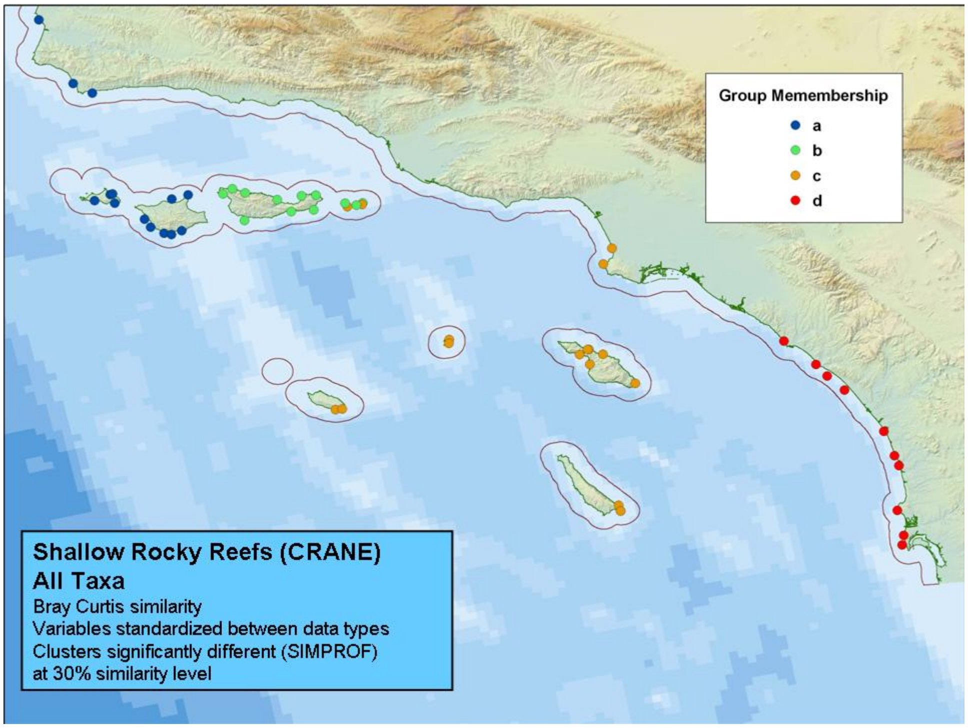


Figure 2-6. Rocky Intertidal Biogeography

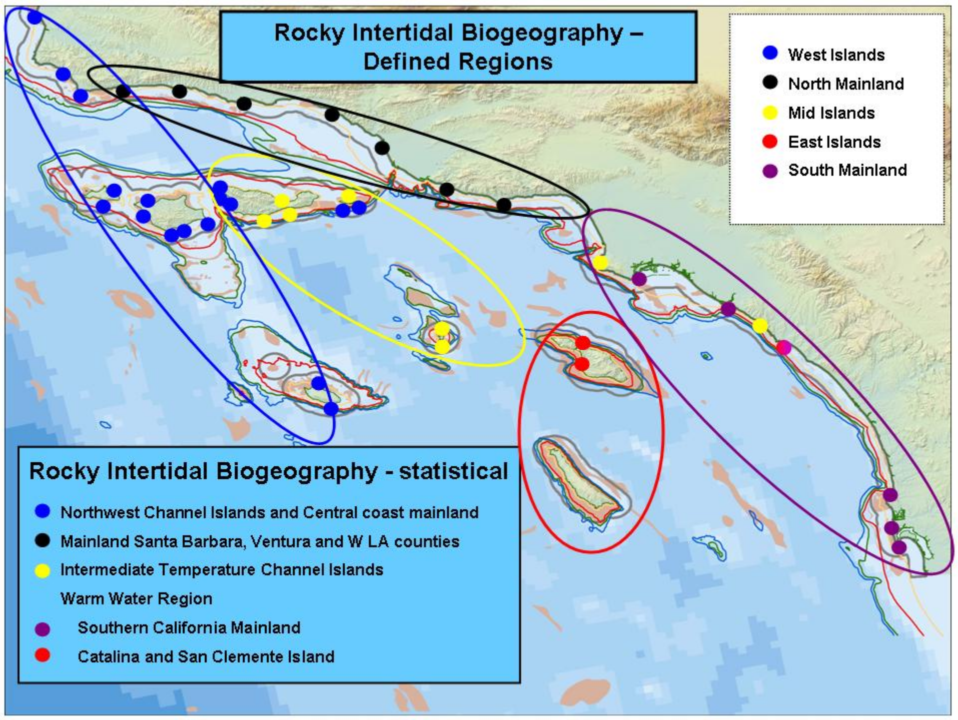


Figure 2-7. Proposed Bioregion Groupings

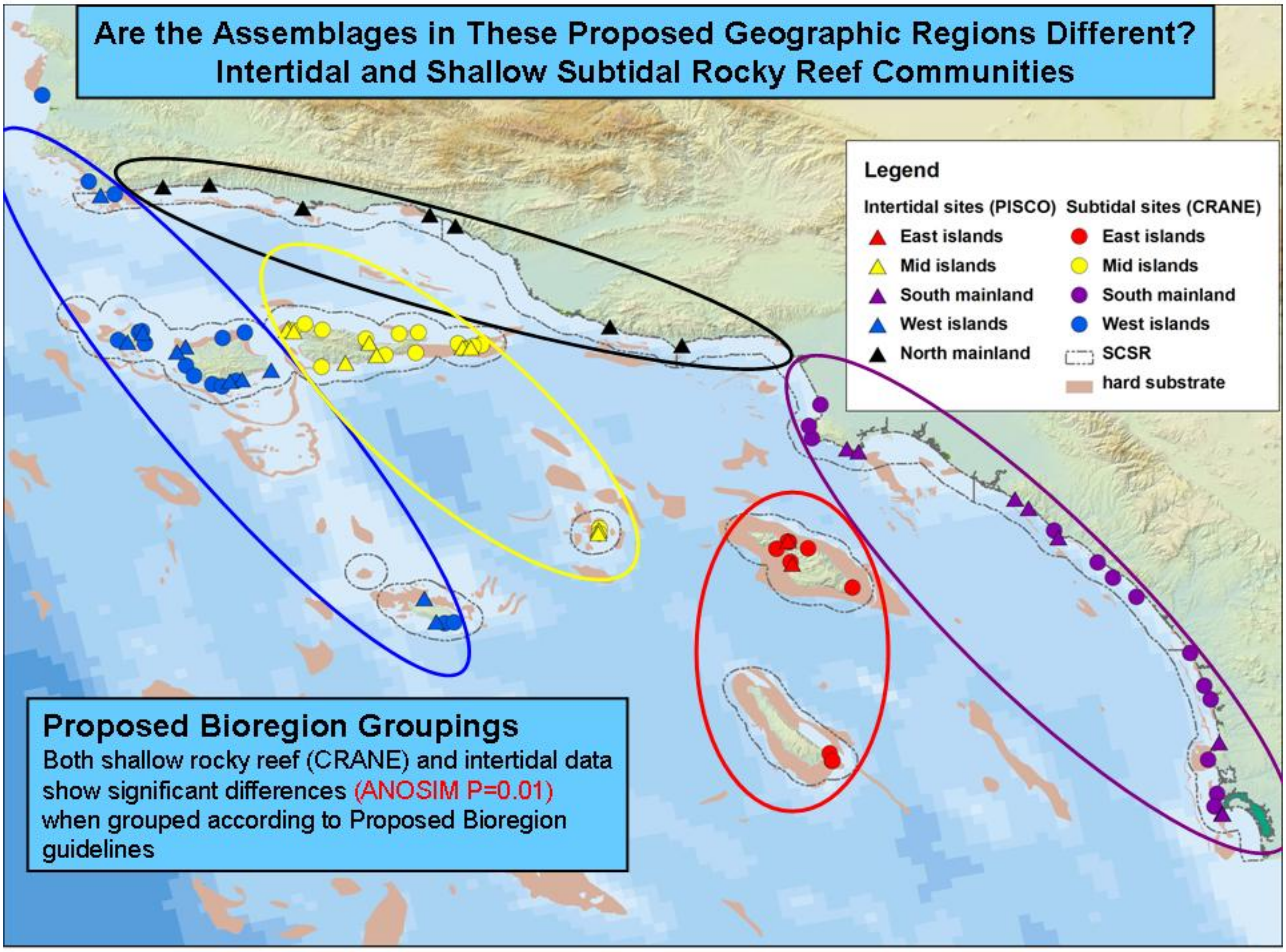


Figure 2-8. Island-Mainland Differences in Kelp Forest Fish Assemblages in the Santa Barbara Channel

Dendrogram illustrates the relative similarities (20%) in relative abundance of reef fish species from sites sampled along the mainland on benthic (MB) and canopy (MC) and island benthic (IB) and canopy (IC) transects, respectively. From Ebeling et al. (1980).

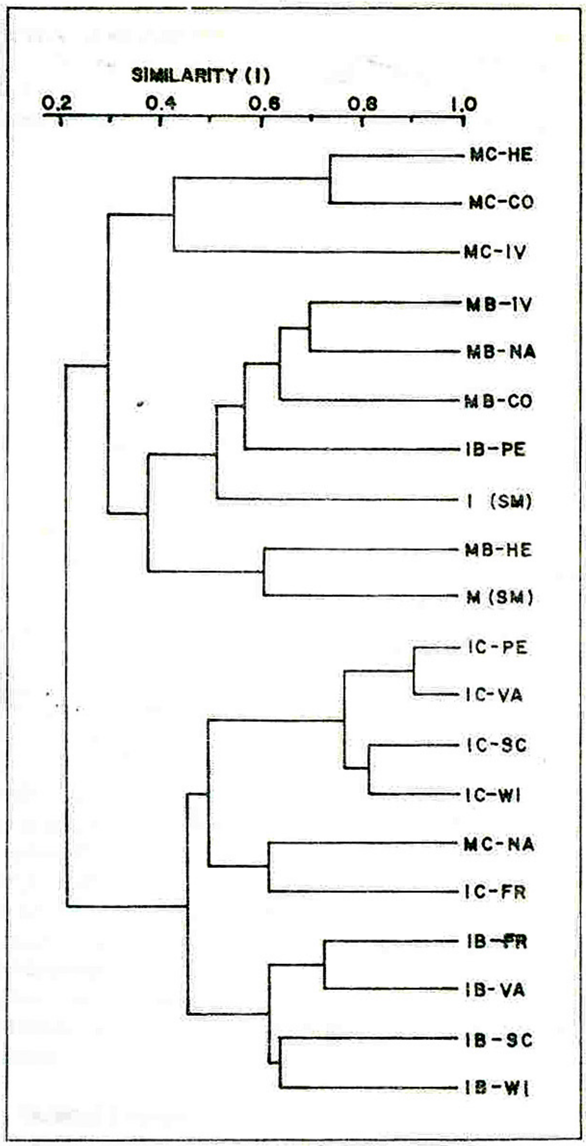


FIGURE 4. *Interlocality cluster analysis of kelp-bed fish assemblages sampled from 175 cinetransects filmed off Santa Barbara. Units are mainland (M) or Santa Cruz Island (I) canopy (C) or bottom (B) samples from the localities (right-hand letter pairs) in Figure 1 and Table 1. The dendrogram was derived from a similarity matrix based on relative species abundances (see text) by means of the unweighted pair-group clustering method using arithmetic averages (Sneath and Sokal 1973).*

Figure 2-9. Proposed Bioregion Group Differences — Shallow Subtidal

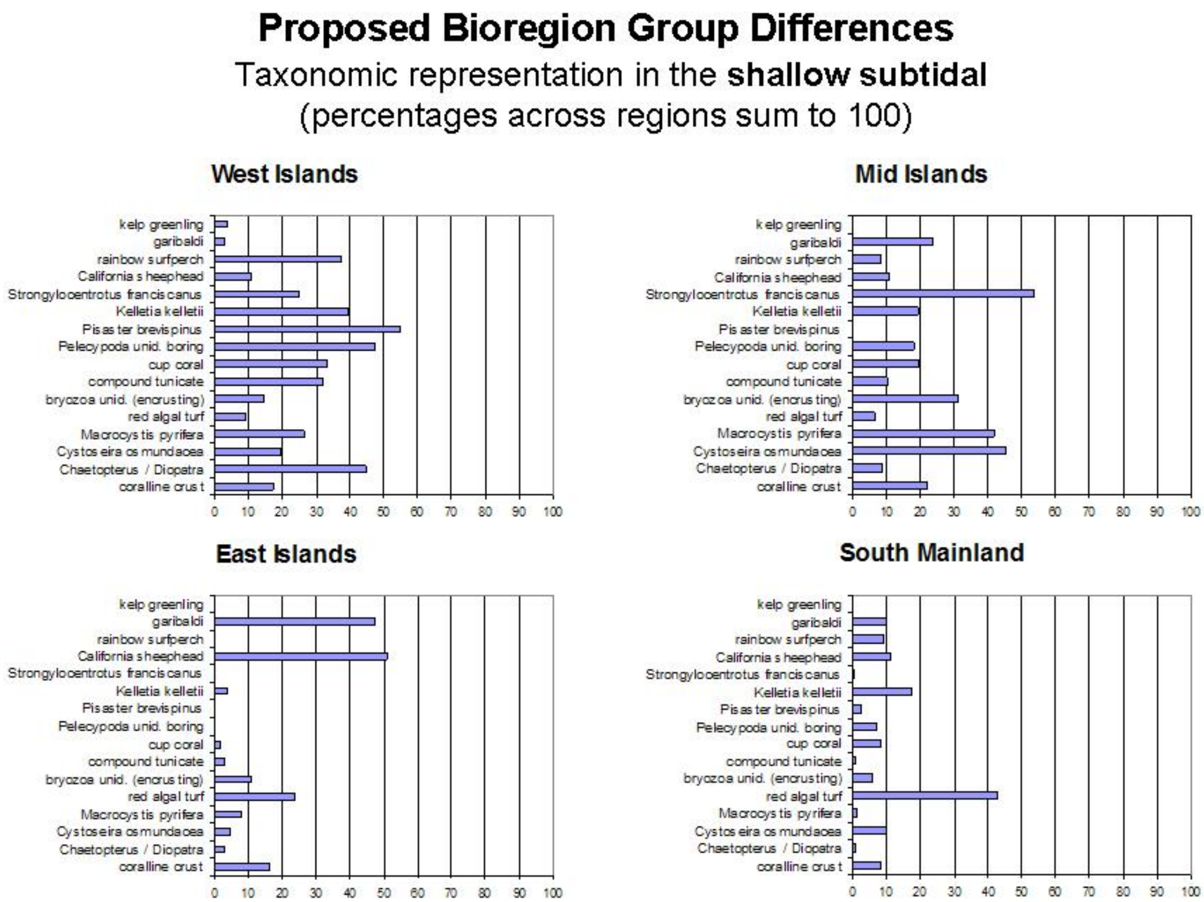
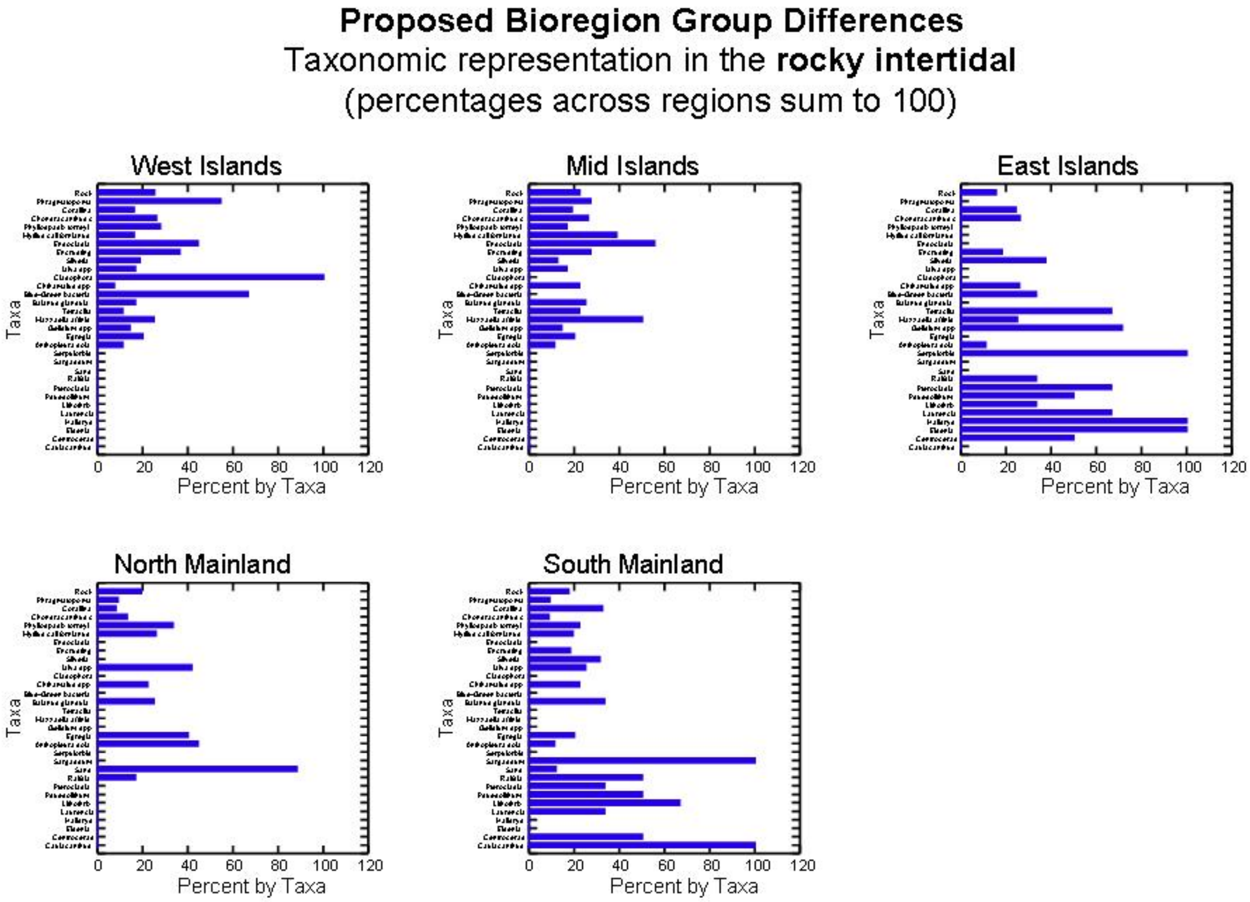


Figure 2-10. Proposed Bioregion Group Differences — Rocky Intertidal



References for Chapter 2

Clarke, K. R and R. E. Warwick. 2001. *Change in marine communities: An approach to statistical analysis and interpretation, 2nd edition.* PRIMER-E Ltd., Plymouth, United Kingdom.

CRANE (Cooperative Research and Assessment of Nearshore Ecosystems), Draft Final Report, Ca. DFG

Ebeling, A.W., R.J. Larson, and W.S. Alevizon. 1980. Habitat groups and island-mainland distributions of kelp-bed fishes off Santa Barbara, California. In D.M. Power ed. *Multidisciplinary Symposium California Islands*. Santa Barbara Museum of Natural History, pages 403-431.

Love, M et al., unpublished data

MARINe (Multi-Agency Rocky Intertidal Network), unpublished data

Murray, S.N. and M.M. Littler. 1981. Biogeographical analysis of intertidal macrophyte floras of southern California. *Journal of Biogeography* 8:339-351.

PISCO (Partnership for Interdisciplinary Studies of Coastal Oceans), unpublished data

Pondella, D.J. II, and L.G. Allen. 2000. The nearshore fish assemblage of Santa Catalina Island. *Proceedings of the Fifth California Islands Symposium*.

Pondella, D.J. II, B.E. Gintert, J.R. Cobb and L.G. Allen. 2005. Biogeography of the nearshore rocky-reef fishes at the southern and Baja California islands. *Journal of Biogeography* 32:187–201.

SCCWRP (Southern California Coastal Water Research Project), *Annual Report*, 2003

3. Protection Levels (Goals 1, 2, 4 and 6)

Status of this chapter: The SAT has approved of the approach presented as the conceptual model in Figure 3-1 and the level of protection designations for the activities included in this chapter.

Summary of the MLPA Guidelines Regarding Level of Protection

The MLPA calls for an improved network of MPAs which includes a "marine life reserve component," and may include "areas with various levels of protection." To facilitate comparison between MPA proposals allowing various uses, the SAT has developed a framework for assessing the level of protection provided by a proposed MPA.

The level of protection (LOP) concept is simple: the more permissive an MPA, the lower its LOP. Permissiveness, as used here, means the degree to which the MPA's regulations permit impacts to habitat or community structure. If a proposed MPA permits activities having high impact on habitat or community structure, then that MPA is said to have a low LOP. An MPA which permitted no human activity at all would on the other hand be said to have a high LOP.

Why Categorize MPAs by Protection Levels?

The SAT needs a method by which to evaluate the overall conservation value of entire proposed arrays of MPAs. Each MPA in a proposal will be designated as one of three types of marine protected areas: state marine reserve (SMR), state marine conservation area (SMCA), or state marine park (SMP). While the SMR, where no appreciable take of any species is allowed, is clearly the most protective of the MPA types, the relationship between the SMCA and the SMP is less clear. There is great variation in the type and magnitude of activities that may be permitted within these MPAs. It is expected that proposals will, in addition to naming each of its MPAs with one of these types, also specify what activities are to be permitted in each MPA. This gives designers of MPA proposals flexibility in crafting MPAs that either individually or collectively fulfill the various goals and objectives specified in the MLPA. However, this flexibility may mean that to evaluate an array of MPAs only by their type designations may lead to deceptive results. For this reason, the SAT looks beyond the MPA type to the proposed permitted activities to determine the LOP an MPA will afford.

Marine Protected Area (MPA) Designations

State marine reserves (SMR) provide the greatest level of protection to species and to ecosystems by prohibiting take of any kind (with the exception of permitted scientific take for research, restoration, or monitoring). The high level of protection attributed to an SMR is based on the assumption that no other appreciable level of take or alteration of the ecosystem will be allowed. Thus, of the three types of MPAs, SMRs provide the greatest likelihood of achieving MLPA goals 1, 2, and 4.

State marine parks (SMP) are designed to provide recreational opportunities and therefore can allow some or all types of recreational take of a wide variety of fish and invertebrate species by various means (e.g. hook and line, spear fishing). Because of the variety of species that potentially can be taken and the potential magnitude of recreational fishing pressure, SMPs that allow recreational fishing provide lower protection and conservation value relative to other, more restrictive MPAs (e.g. SMRs and some SMCAs). Although SMPs may have lower value for achieving MLPA goals 1 and 2, they may assist in achieving other MLPA goals.

State marine conservation areas (SMCA) potentially have the most variable levels of protection and conservation of the three MPA designations because they may allow any combination of commercial and recreational fishing, as well as other extractive activities (e.g. kelp harvest).

Conceptual Framework for Assigning Levels of Protection

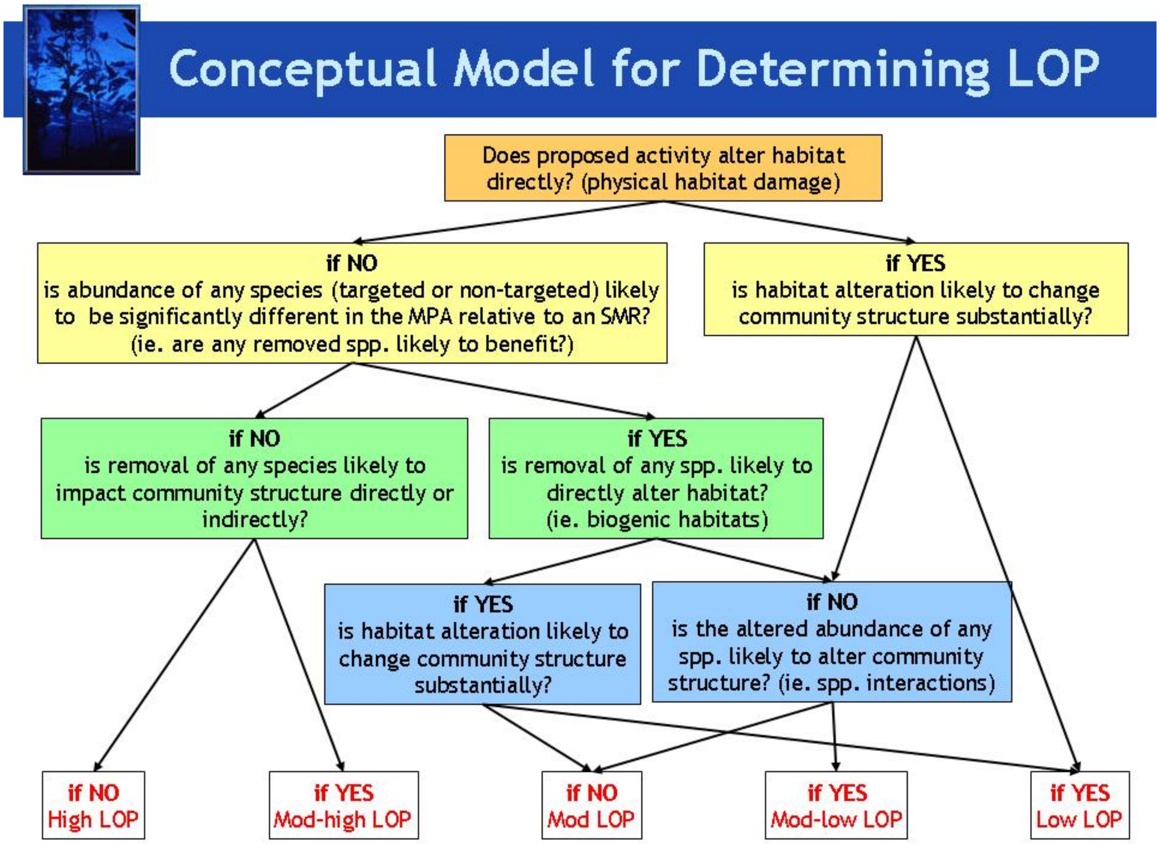
Levels of protection are based upon the likely impacts of proposed activities to the ecosystems within the MPA. Conceptually, the SAT seeks to answer the following question in assigning levels of protection: “How much will an ecosystem differ from an unfished ecosystem if one or more proposed activities are allowed?” To arrive at answer, the SAT will evaluate each activity that is proposed to be permitted in an MPA, asking “How much will this ecosystem differ from an unfished system if this one activity is allowed?” Where multiple permitted activities are proposed, the one with the greatest impact is the one that will “win,” meaning that the LOP ascribed to the MPA will be the LOP that would result if that single, highest-impact activity were the only one allowed.

Marine reserves (SMRs) are, by definition, unfished ecosystems, therefore we ascribe to them the highest protection level, “very high.” To MPAs that allow extractive activities are ascribed levels of protection ranging from “high” for low-impact activities, to “low” for activities that alter habitat and thus are likely to have a large impact on the ecosystem. Both direct impacts (those resulting directly from the gear used or removal of target or non-target species) and indirect impacts (ecosystem-level effects of species removal) are considered in the levels of protection analysis. Figure 3-1 presents the decision flow for determining the level of protection of a proposed MPA based on one permitted activity. It asks questions about the activity so as to result in a LOP designation for the MPA where that activity will be allowed. This same decision flow will be used for every activity that is proposed to be permitted, so that the one resulting in the lowest LOP designation for a particular MPA is the one that will determine the LOP designation actually assigned.

As the term is used here, “activity” refers to:

- take of a particular species,
- by a particular method,
- at a particular range of depths.

Figure 3-1. Conceptual Model for Determining the Level of Protection in an MPA Based on an Extractive Activity Permitted There



In applying the conceptual model presented in Figure 3-1 the SAT makes three important assumptions:

- Any extractive activity can occur at high intensity.
- For the purpose of comparison, an unfished system is a marine reserve that is successful in protecting that ecosystem from all effects of fishing and other extractive uses within the MPA.
- The proposed activity is occurring in isolation (i.e. without cumulative effects of multiple allowed activities).

The SAT identifies the impacts of a proposed activity by considering two main categories of impacts: (1) direct impacts of the activity, and (2) indirect impacts of the activity on community structure and ecosystem dynamics. In the case of fishing, direct impacts may include habitat disturbance and removal of target and non-target species caused by the fishing gear or method. Indirect impacts may include any change in the ecosystem caused by removal of target and non-target species. In general, removal of resident species that are likely to benefit from MPAs are considered to have impacts on species interactions, especially if those species play an integral role in the food web or perform a key ecosystem function (e.g. biogenic structure).

Associated Catch

To consider the catch associated with specific gear types and target species, the SAT examined five sources of data in the analysis: 1) California Recreational Fisheries Survey angler interviews (CRFS interviews), 2) CRFS onboard observer data (CRFS observer data), 3) DFG commercial landing receipt data, 4) DFG log book data from recreational commercial passenger fishing vessels (CPFVs), and, where adequate scientific information was lacking, 5) input from stakeholders familiar with relevant species or fisheries.

The CRFS data, commercial landing receipt data, and CPFV log book data are all limited in their ability to accurately reflect 'bycatch' because catch information is not clearly linked to a specific target species. Bycatch, in this document, means fish or other marine life that are taken (both landed and discarded) in a fishery but which are not the target of the fishery. CRFS angler interviews, commercial landing receipt data, and CPFV log book data all report catch at the trip level, with a single target per trip. Anglers may switch target species during a trip and retain a mixed species catch but this shift in effort to a different target species is not always captured in the data. For example, an interviewed angler or CPFV logbook may report yellowtail as the primary target but may have switched fishing effort to target kelp bass during the trip. Both yellowtail and kelp bass may have been retained, but at the trip level there is insufficient resolution in the data to determine if those kelp bass were caught incidentally while fishing for yellowtail, or were caught cleanly in a separate fishing event on the same trip. In the case of CRFS onboard observer data, the fishing target is not indicated, only the catch is recorded, which further complicates efforts to identify incidental catch. Due to the inability of these data to accurately reflect 'bycatch,' the term 'associated catch' is used in reference to data where it can not be determined if the reported catch was incidental to fishing for the target species. Associated catch is defined in this document as the removal or mortality of species other than the declared target species and includes any organisms that are: 1) captured incidentally in a fishery whether they are discarded (either dead or alive), kept for personal use, or sold; or 2) captured as a secondary target species where it could not be determined if effort shifted to a secondary target species.

The CRFS data used in this analysis may provide a better estimate of associated catch than commercial landing receipt data because it includes both landed and discarded catch. However, the CRFS data only reflect sampled trips, and are not expanded for total effort. CRFS observer data consist of observations of landed and returned catch by a trained CRFS observer sampling a sub-set of anglers fishing at each location on sampled trips. CRFS interview data include both examined catch and catch that was not examined by a sampler but reported by anglers as discarded either dead or alive. CRFS data are reported as numbers of fish.

Commercial landing receipts only provide data for species that were landed and brought to market. Discarded catch is not reported on landing receipts and was not available for this analysis. Thus, the commercial landing receipt data are likely to provide a reasonable estimate of associated catch only for marketable species that are legal to retain in conjunction with the primary target species. Again, commercial fishermen may switch target species during a trip and report those on a single landing receipt. For each trip in which a given species made up the largest proportion of the catch, those species and all other species reported on the same landing receipts using similar gear are represented as a percent of the landed catch. Ecological impacts may result from removal of all of the species considered here as “associated catch.”

Logbook data from CPFV recreational fishing trips in the study region report the number of landed and discarded target species as well as incidental catch and, in many cases, the depth where the majority of the catch was taken. However, in some cases it may be possible that a single target species was recorded for a trip where effort shifted to a secondary target species that was not recorded as a target. The data from those trips would be considered “associated catch” rather than “bycatch.”

Throughout this analysis, the associated catch for a fishery was only one consideration of the ecological consequences of that activity. As described above, in determining the level of protection to assign to an activity, the SAT considered both direct and indirect impacts, such as habitat disturbance or removal of individuals from the ecosystem, and the consequences those individuals may have on the ecosystem or community dynamics.

Levels of Protection for the South Coast Study Region

The levels of protection as they apply to the south coast study region are presented below. For an MPA that allows multiple activities, the lowest LOP designation resulting from any allowed activity is the one assigned to that MPA. The SAT acknowledges that multiple uses within an MPA may have cumulative impacts on the ecosystem that exceed those of the individual activities. Such cumulative impacts are difficult to predict and the SAT has not addressed this concern in assigning levels of protection.

Very High – no take of any kind allowed. This designation applies only to SMRs.

High – Proposed activities were assigned this level of protection if the SAT concluded that the activity: 1) does not directly alter habitat, 2) is unlikely to significantly alter the abundance of any species relative to an SMR, and 3) is unlikely to have an impact on community structure relative to an SMR. The mobility of removed species (both target and associated catch) was an important factor in determining the activity’s impact on abundance and community structure. Individuals of highly mobile species are expected to move frequently between MPAs and unprotected waters, so local abundance of these species is unlikely to be different in a fished area relative to an SMR. Altered abundance of a species, and the associated changes in ecological interactions (e.g. predator/prey, competitive, or mutualistic relationships) are what drives changes in community structure. If the proposed activity is unlikely to alter the abundance of *any* species relative to an SMR, community structure is expected to be unaltered as well and the activity is expected to have little impact on the ecosystem.

Moderate-high – Activities were assigned this level of protection if the SAT concluded that the activity: 1) does not directly alter habitat, 2) is unlikely to significantly alter the abundance of any species relative to an SMR, but 3) has some potential to alter community structure relative to an SMR. Activities assigned this level of protection are generally characterized by substantial uncertainty regarding ecosystem impacts. This uncertainty arises in one of three ways: 1) the movement range of the target species is either uncertain or short enough that reserve effects are possible, yielding uncertainty as to whether the abundance of this species will be altered relative to an SMR, 2) the level or composition of incidental catch is uncertain making it unclear whether the abundance of any non-target species will be altered relative to an SMR, or 3) the ecological role of any removed species is unclear, leading to uncertainty about how removal may alter community structure relative to an SMR.

Moderate – Activities were assigned to this level of protection if the SAT concluded that the activity was likely to alter either habitat or species abundance in the area relative to an SMR, but that these changes were unlikely to impact community structure substantially. Activities that are likely to cause minor habitat perturbations or alter the abundance of species that play a minor ecological role (e.g. one of many prey items) received this level of protection.

Moderate-low – Activities were assigned to this level of protection if the SAT concluded the activity was likely to: 1) alter species abundance relative to an SMR, and 2) alter community structure significantly through the change in abundance of a species that plays an important ecological role (e.g. top predator) but does not form biogenic habitat. Activities assigned this level of protection may also alter habitat if that habitat alteration is unlikely to have a significant impact on community structure.

Low – Only activities that alter habitat in a way that is likely to significantly alter community structure were assigned to this level of protection. Activities with the potential to alter habitat substantially either through direct contact with fishing gear or removal of habitat-forming organisms received this low level of protection.

Table 3-1. Level of Protection and the Activities Associated with Levels of Protection in the MLPA South Coast Study Region

	Level of Protection	MPA Type	Activities Associated with a Protection Level
	Very high	SMR	No take
	High	SMCA	Coastal pelagic finfish, bonito, and market squid (pelagic seine, dip-net, crowder); jumbo squid (squid jigs); swordfish (harpoon); **In water depth > 50m:** pelagic finfish, bonito and white seabass (H&L; spear at any depth)
	Moderate-high	SMCA	Catch and release in <10m water or using surface gear (H&L single barbless hooks and artificial lures only); pier-based fishing (H&L, hoop-net); halibut (spear); **In water depth 30<50m <u>on mainland</u>:** pelagic finfish, bonito and white seabass (H&L)
	Moderate	SMCA SMP	spot prawn (trap/pots); sea cucumber (scuba/hookah); grunion (hand harvest); giant kelp (hand harvest); clams (hand harvest)

	Moderate-low	SMCA SMP	Catch and release in >10m (H&L); shore-based finfish (H&L); kelp bass, barred sand bass, lingcod, cabezon, and rockfish (H&L, spear); sheephead (H&L, spear, trap); spotted sand bass and halibut (H&L); lobster (trap, hoop net, scuba); urchin (scuba/hookah); rock crab and Kellet's whelk (trap); **In water depth <50m at islands and <30m on mainland:** pelagic finfish, bonito and white seabass (H&L)
	Low	SMCA SMP	rock scallop (scuba); mussels (hand harvest); giant kelp (mechanical harvest); marine algae other than giant and bull kelp (hand harvest)

Only SAT-approved designations are included in this table. It should be noted that staff is working with the SAT to coordinate terminology for particular gear types that is consistent with both the activities being proposed by the RSG and as defined in regulations under California Fish and Game Code. Thus the descriptions here may change in a future version of this document.

Coastal MPAs are most effective at protecting species with limited range of movement and close associations to seafloor habitats. Less protection is afforded to more wide-ranging, transient species like salmon and other pelagics (e.g. albacore, swordfish, pelagic sharks). This has led to proposals of SMCAs that prohibit take of bottom-dwelling species, while allowing the take of transient pelagic species. However, fishing for some pelagic species, near the sea floor or over rocky substrate in relatively shallow water, may increase the likelihood of inadvertently catching resident species that are likely to otherwise receive protection within the MPA. Although depth- and habitat-related bycatch information for specific fisheries are not readily available, it is likely that bycatch is highest in shallow water where bottom fish move close to the surface and become susceptible to the fishing gear.

Participants at a national conference[11] on benthic-pelagic coupling considered the nature and magnitude of interactions among benthic (bottom-dwelling) and pelagic species, and the implications of these interactions for the design of marine protected areas. At this meeting, scientists, managers, and recreational fishing representatives concluded that bycatch is higher in depths where seafloor is <50m (27 fathoms,164 ft) and is lower in depths where seafloor is >50m. This information, along with associated-catch information provided by DFG, contributed to SAT's categorization of MPAs into levels of protection.

The SAT's LOP Designations for Potential Allowed Uses

The Science Advisory Team considers each potential allowed use individually to arrive at the decisions summarized in Table 3-1. A complete decision matrix of all uses for which an LOP designation has been approved by the SAT is in Appendix A of this document. This subsection presents an in-depth description of the rationale for each decision made by the SAT.

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[11] Benthic-pelagic linkages in MPA design: a workshop to explore the application of science to vertical zoning approaches. November 2005. Sponsored by NOAA National Marine Protected Area Center, Science Institute, Monterey, CA.

It should be noted that the following explanations are only those approved thus far by the SAT. The matrix in Appendix A includes decisions for which the full textual explanation, as given in this subsection, will appear in the following revision of this document.

Pelagic finfish,[12] Pacific bonito, and white sea bass (hook and line or spear)

Direct impacts – Take of pelagic finfish by hook and line is unlikely to alter habitat directly as gear rarely touches the seafloor.

Pelagic finfish targeted in the study region, include yellowtail, barracuda, dorado, mackerel, marlin, swordfish, mako and thresher sharks, and albacore, yellowfin, bluefin, and skipjack tunas. Pacific bonito (*Sarda chiliensis*) and white seabass (*Atractoscion nobilis*) are not defined as pelagic finfish in California regulations, but they share many characteristics with the above species and are often caught in conjunction with other pelagics. Pelagic finfish are highly mobile species that are unlikely to benefit directly from MPAs constrained within state waters, thus the abundance of these species is unlikely to be altered in an area that allows take relative to a state marine reserve (SMR).

Fishing for pelagic finfish with spear gear requires visual contact with the target, thus the incidental catch in this fishery is likely to be minimal. Data on associated catch of pelagic finfish using hook and line gear were extracted from commercial passenger fishing vessel (CPFV) observer data collected by DFG, but were difficult to interpret because they do not resolve the targeted species. Observer catch records for bonito, mackerel, yellowtail, white seabass, and barracuda all indicate a high associated catch of basses (kelp bass and barred sand bass) and other reef-associated fishes, including rockfish, halfmoon, scorpionfish, and sheephead. CPFV angler interview data (which resolves catch by target but does not account for target switching within a trip) confirms the associated catch relationship between pelagic finfish and nearshore resident species. If associated catch of resident species is substantial, the abundance of these species may be altered by take of pelagic finfish relative to an SMR.

Catch information was insufficient to assess the magnitude of incidental catch, or how it correlates with gear type, depth, or habitat. However, the primary gear and methods used to take pelagic finfish are virtually identical to those used when targeting nearshore resident species, such as kelp bass and barred sandbass. Thus the SAT concluded that avoidance of shallow nearshore habitats was the only way to reliably reduce incidental catch of resident species. The SAT used the depth distribution of kelp forests and sandbass

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[12] Pelagic finfish: northern anchovy (*Engraulis mordax*), barracudas (*Sphyraena* spp.), billfishes* (family Istiophoridae), dolphinfish (*Coryphaena hippurus*), Pacific herring (*Clupea pallasi*), jack mackerel (*Trachurus symmetricus*), Pacific mackerel (*Scomber japonicus*), salmon (*Oncorhynchus* spp.), Pacific sardine (*Sardinops sagax*), blue shark (*Prionace glauca*), salmon shark (*Lamna ditropis*), shortfin mako shark (*Isurus oxyrinchus*), thresher sharks (*Alopias* spp.), swordfish (*Xiphias gladius*), tunas (family Scombridae), and yellowtail (*Seriola lalandi*). *Marlin is not allowed for commercial take.

breeding aggregations to delineate depth zones where incidental catch of resident species was more or less likely.

Indirect impacts – Pelagic finfish generally feed on mobile forage species such as small schooling fishes, crab larvae, squid, shrimps and planktonic organisms. As both pelagic finfish and their prey are highly mobile, MPAs are likely to have little impact on the local abundance of these species. Thus, the indirect ecosystem impacts of pelagic finfish take are predicted to be low.

Level of protection:

High – spear, any depth

High – hook and line, if water depth in MPA is greater than 50m; and

Mod-high – hook and line surface gear on mainland if water depth in MPA is less than 50m but greater than 30m due to potential increase in associated catch of resident species

Mod-low – hook and line if water depth is less than 30m on the mainland or 50m at the islands

Rock scallop (scuba hand collection)

Direct impacts – Hand collection of rock scallops (*Crassadoma gigantea*) is done in one of two ways. Either the diver cuts the scallop from it's shell underwater, leaving the shell attached to the rock, or the diver pries the scallop, shell and all, from the rock. Either method causes some habitat disturbance, but prying the shell from the rock causes damage to the reef as well as removing the habitat formed by the scallop shell. The removal of rock scallops is likely to have an impact on community structure by altering reef structure and habitat for benthic invertebrates.

Rock scallops are a sessile bivalve that inhabits rocky reefs. Due to their sessile nature rock scallops are likely to benefit directly from MPAs within state waters, therefore harvest of rock scallops is likely to alter their abundance relative to an SMR.

Because divers harvest selectively, there is little or no catch of non-target species.

Indirect impacts – Rock scallops are planktivores and prey to sea stars and shell borers in the nearshore rocky environment. Removal of this species is likely to have moderate impacts on community structure within an MPA.

Level of protection:

Low

Urchin hand collection

Direct impacts – Hand collection of urchins causes some habitat disturbance (divers may move rocks to better remove the urchins) but these habitat effects are unlikely to alter community structure significantly.

Several species of sea urchins inhabit shallow rocky reefs along the coast of California. The two most abundant species on shallow rocky reefs throughtout the coast of California are the red and purple sea urchin (*Strongylocentrotus franciscanus* and *purpuratus*, respectively). In southern California, two other species can be locally abundant on rocky reefs, the crowned sea urchin, *Centrostephanus coronatus* and the white sea urchin, *Lytechinus anamesus*. The red urchin is the only species taken commercially in California waters. All but the white sea urchin are relatively sedentary species. Thus, the abundance of red sea urchins within an area may be altered by harvest relative to an SMR, depending on the level of protection and rates of predation by other sea urchin predators. However, divers harvest selectively so there is little or no catch of non-target species.

Indirect impacts – Urchins are ecologically important species in most shallow rocky ecosystems (Lawrence 1975, Harrold and Pearse 1987). They can be important herbivores, prey, competitors and facilitators of other species in nearshore rocky habitats. Throughout their range, populations of sea urchins can impact (decrease) the abundance of macroalgae, thereby altering both the total abundance of macroalgae, the relative abundance of species of macroalgae in a kelp forest, and the abundance of invertebrates and fishes associated with habitats created by macroalgae (Graham 2004, Graham et al 2008). Sea urchins feed on both drift (i.e. detached) and attached growing macroalgae. Their impact on the local abundance of drift and attached algae is a function of their local abundance, food availability and abundance of their predators. In low abundance, with sufficient drift availability and the presence of predators, red sea urchins restrict their distribution to crack and crevices and feed on drift. With insufficient drift abundance (Ebeling et al 1985, Harrold and Reed, 1985, Tegner and Dayton 1991) or reduced predator abundance (Cowen 1983), red sea urchins emerge from cracks and crevices and form “feeding fronts” that remove all macroalgae where they travel (see Table 2 in Harrold and Pearse, 1987). Other triggers of destructive grazing events include episodes of strong recruitment of sea urchins and loss of abundant drift caused by reduction of kelp by other factors (storms, El Niño events, grazing amphipods).

Adult sea urchins are eaten by several predators in shallow rocky reefs, including the sea otter, *Enhydra lutris*, wolf eel, *Anarrhichthys ocellatus*, California spiny lobster, *Panulirus interruptus* (Tegner and Levin 1983, Berhens and Lafferty 2004), California sheephead, *Semicossyphus pulcher* (Cowen 1983), sunflower sea star, *Pycnopodia helianthodes*, and other species. Small sea urchins are eaten by other predators (e.g., other sea stars, crabs and other species). Three lines of evidence from the south coast study region suggest that these predators, when they occur in sufficient abundance, can control/suppress the abundance of their sea urchin prey. In one marine reserve in the northern Channel Islands (Anacapa Island), spiny lobster and California sheephead were more numerous, sea urchin density was lower and the abundance of giant kelp, *Macrocystis pyrifera*, was higher than areas outside the reserve (Behrens and Lafferty 2004). Similarly, after five years of protection, an increase in kelp abundance has been observed within the Channel Islands MPAs compared to adjacent areas, though there is no direct evidence for a trophic basis for this response (B. Kinlan pers Comm., The First Five Years of Monitoring the Channel Islands Marine Protected Area Network) Thirdly, between the extirpation of sea otters and the advent of the sea urchin fishery, kelp forests were extensive in southern California demonstrating that other factors besides fishermen controlled sea urchins (Crandall 1912). These interactions between multiple predators (including man) and their prey, suggest that these predators may compete for sea urchins. Thus, the local impacts of human take may diminish the local growth, reproduction and abundance of the other predators of sea urchins in a marine protected area. In addition, at high densities, sea urchins experience high mortality from disease (Lafferty 2004) reducing the local abundance of sea urchin populations.

Sea urchins compete with other herbivores for both drift and intact algae. They also compete with other species for refuge from predators in cracks and crevices. In particular, sea urchins compete with abalone for both drift algae and refuge space (Karpov et al. 2001). In contrast, red sea urchins serve as nursery sites for other small invertebrates, protecting them from predators during their vulnerable life stages. Young abalone seek shelter beneath the spines of red sea urchins and the density of abalone recruits can be greater in northern California MPAs where red sea urchins are protected from take[13].

Based on the various species interactions described above, removal of urchins by urchin harvest is likely to have impacts on community structure, especially the total and relative abundance of other sea urchin predators, within an MPA.

Level of protection:

Moderate-low – due to indirect ecosystem effects

Spot prawn (trap):

Direct impacts – Take of California spot prawn (*Pandalus platyceros*) with traps involves bottom contact but is unlikely to alter habitat.

Spot prawn are a moderately mobile species (Boutillier and Bond, 2000) which may benefit directly from MPAs within state waters. Tagging studies of spot prawn from British Columbia show that individuals remain within a mile or two of their release location over several months (Boutillier, unpublished data). This finding is supported by a study that found significant differences in parasite loads between populations separated by only 10s of kilometers (Bower and Boutillier, 1990). The moderate adult movement of spot prawn indicates that the abundance of spot prawn is likely to be lower in a fished area as compared to a no-take marine reserve. No data on associated catch for the spot prawn

[13] Rogers-Bennett, L. and J.S. Pearse. 2001. Indirect Benefits of Marine Protected Areas for Juvenile Abalone. Conservation Biolology. 15(3):642-7.

fishery were examined, but data from other trap fisheries (Dungeness crab in the north central coast) indicates that bycatch in the trap fishery is likely to be low, thus the fishing activity is unlikely to alter the abundance of any non-target species.

Indirect impacts – Spot prawn are micro-predators, feeding on other shrimp, plankton, small mollusks, worms, sponges, and fish carcasses. In turn, spot prawn are one of many available prey items for fishes and marine mammals. Any change to ecological interactions caused by reduced abundance of spot prawn is likely to have only minor impacts on community structure within an MPA.

Level of protection: **Moderate**

Sea cucumber (scuba/hookah hand collection):

Direct impacts – Hand collection of sea cucumber (*Parastichopus parvimensis*) has the potential to alter habitat (anchoring and search activities can disturb both rock and kelp as habitat), but habitat alterations are unlikely to have a significant impact on community structure.

Sea cucumber are relatively sedentary bottom-dwelling species that are likely to benefit directly from MPAs within state waters. A study conducted in the northern Channel Islands before and after the onset of the sea cucumber dive fishery showed a significant decline in sea cucumber abundance at fished sites after the onset of fishing, relative to two no-take marine reserves on Anacapa Island (Schroeder et. al. 2001). The low adult movement of sea cucumber indicates that the abundance of sea cucumber is likely to be lower in a fished area as compared to a no-take marine reserve. Because divers harvest selectively, there is little or no catch of non-target species, thus the fishing activity is unlikely to alter the abundance of any non-target species.

Indirect impacts – Sea cucumbers are detritivores and prey for sea stars (especially Pycnopodia) in the nearshore rocky environment. Any change to ecological interactions caused by reduced abundance of sea cucumber is likely to have only minor impacts on community structure within an MPA.

Level of protection: **Moderate**

Grunion (hand collection):

Direct impacts – Collecting grunion (*Leuresthes tenuis*) by hand from beaches is unlikely to alter habitat.

Grunion are a highly mobile species that is unlikely to benefit from MPAs constrained within state waters unless those MPAs protect spawning sites. Genetic studies of grunion indicate panmixia within the Southern California Bight (Gaida et al, 2003) and high genetic similarity between populations in San Francisco Bay and Los Angeles (Johnson et al, 2009). These genetic studies support the conclusion that grunion are highly mobile. However, collecting grunion by hand on spawning beaches targets this species during the vulnerable spawning period. Unlike squid, which also form spawning aggregations, grunion spawn multiple times in a single season, and may display natal homing, returning to breed at the beach where they were spawned (Martin, K., personal communication). Due to natal homing and spawning aggregations, the abundance of spawning grunion may be altered by hand collection relative to an SMR. Because collectors harvest selectively, there is little or no catch of non-target species, thus the fishing activity is unlikely to alter the abundance of any non-target species.

Indirect impacts – Although grunion are a highly mobile pelagic species they form spawning aggregations and deposit large numbers of eggs on sandy shores. Spawning grunion and their eggs are important, if sporadic, prey in the nearshore ecosystem, thus an altered abundance of grunion may have some minor impacts on the beach community but is unlikely to change community structure significantly.

Level of protection: **Moderate**

Kelp bass (hook and line or spear):

Direct impacts – Take of kelp bass (*Paralabrax clathratus*) by hook and line or spear is unlikely to alter habitat as gear rarely touches the seafloor.

Kelp bass are demersal fish that occur on nearshore rocky reefs and kelp forests. Several studies have shown kelp bass to have small home range sizes. Tag recapture studies conducted by the California DFG in the 1940s and 50s showed that 80% of fish move on the order of 1-2 km although some individuals moved hundreds of kilometers, possibly in search of better habitat (Collyer & Young 1953) (Young 1963) (Quast 1968). More recent studies using acoustic telemetry have confirmed these results, indicating that most kelp bass utilize a small core area (average 0.003 km^2), although some individuals made excursions from this core of one km or more (Lowe et al 2003). Using passive acoustic telemetry methods, Mason (2008) found that kelp bass tagged in the small (0.06 sq mile) Catalina Marine Science Center Reserve were detected within the reserve 317 days out of the subsequent year. Increases in the size and abundance of kelp bass have been demonstrated in a number of small MPAs in Southern California (Tetreault and Ambrose 2007) (Froeschke et al 2006). Tetreault and Ambrose examined kelp bass populations in five small (all $< 2\ km^2$) marine reserves and found that on average, kelp bass were 2.8 times more abundant and 1.4 times larger inside the reserves as compared to nearby control sites. Additionally, Froeschke et al. found kelp bass densities were significantly higher inside the Catalina reserve as compared to control sites outside the reserve. These studies support the conclusion that kelp bass are relatively sedentary and that their abundance is likely to be altered by take relative to an SMR.

CRFS observer and interview data indicate that kelp bass catch using hook and line gear is often associated with catch of other resident reef species including barred sand bass, sheephead, halfmoon, blacksmith, and several nearshore rockfish species. This indicates that the abundance of non-target species may also be altered by hook and line fishing for kelp bass. No data was examined to determine associated catch using spear gear, but a targeted spear fishery is unlikely to produce incidental catch of non-target species.

Indirect impacts – Kelp bass are top predators on nearshore rocky reefs, so that their removal of this species is likely to have impacts on community structure within an MPA. Kelp bass are carnivorous ambush predators, feeding on a variety of small fish and invertebrates including other kelp bass, pipefishes, flatfishes, blacksmith, surfperch, crabs, squid, polychaetes, tunicates, and hydrozoans. Kelp bass also scavenge urchins from sheephead attacks.

Level of protection: **Moderate-low**

Barred sand bass (hook and line or spear):

Direct impacts – Take of barred sand bass (*Paralabrax nebulifer*) by hook and line or spear is unlikely to alter habitat as gear rarely touches the seafloor.

Barred sand bass are demersal fish which occur in mixed sandy and rocky habitat and are often associated with kelp and seagrass beds or artificial reefs. The movements of barred sand bass are not well known. DFG (1982) tagging studies from the 1980s indicate movements from five to 40 miles but more recent acoustic tagging studies from a small marine reserve on Catalina Island show that at least some barred sand bass stay within a small area most of the year (Mason 2008). In this study, eight barred sand bass were tagged within the small (0.06 sq mile) Catalina Marine Science Center Reserve. These tagged fish were detected inside the reserve an average of 314 days out of the subsequent year. Another study showed a significant increase in the density of barred sand bass inside the small (0.04 sq mile) Heisler Park Reserve as compared to nearby control sites (Tetreault & Ambrose 2007), indicating that barred sand bass may be sufficiently sedentary to benefit directly from MPAs. During the breeding season (May-August), barred sand bass are known to form breeding aggregations in soft-bottom habitats ranging from 20-30m depth (Baca Hovey et al 2002) but it is unclear how far they move to reach these breeding sites. The locations of many barred sand bass breeding sites are known and the aggregations are often targeted by the recreational fishery; thus barred sand bass are likely to benefit from MPAs that protect their breeding sites. Due to breeding aggregations and likely low adult movement, catch of barred sand bass is likely to alter their abundance relative to an SMR.

Indirect impacts – Barred sand bass are important predators in the nearshore environment, so removal of this species is likely to have impacts on community structure within an MPA. Barred sand bass are carnivorous ambush predators, feeding on a variety of small fish and invertebrates including surfperch, sardines, anchovies, midshipman, crabs, clams, and squid.

Level of protection: **Moderate-low**

California sheephead (hook and line, spear, or trap):

Direct impacts – Take of California sheephead (*Semicossyphus pulcher*) by hook and line or spear is unlikely to alter habitat as gear rarely touches the seafloor. Use of trap gear involves bottom contact but is also unlikely to alter habitat significantly.

Sheephead are demersal fish which occur on nearshore rocky reefs and kelp forests. The movements of sheephead have not been studied extensively, but existing studies indicate that they have high site fidelity and a small home range. Topping et al (2005) used acoustic tags to monitor the movement of sheephead within the small (0.06 sq mile) Catalina Marine Science Center Reserve. The 16 sheephead in this study used a small core area (average 0.015 km^2) and were detected within the reserve 266 days over the subsequent year. Increases in the size and abundance of sheephead have been demonstrated in a number of small MPAs in southern California. Tetreault and Ambrose (2007) examined sheephead populations in five small (all < 2 km^2) marine reserves and found that on average, male sheephead were 3.7 times more abundant and 1.2 times larger inside the reserves as compared to nearby control sites. Female sheephead were 1.6 times more abundant and 1.3 times larger inside reserves as compared to control sites. Additionally Froeschke et al. (2006) found that sheephead densities were significantly higher inside the Catalina reserve as compared to control sites outside the reserve. These studies support the conclusion that sheephead abundance is likely to be altered by take relative to an SMR.

Indirect impacts – Sheephead are important predators on nearshore rocky reefs, so removal of this species is likely to have impacts on community structure within an MPA. Sheephead are carnivores with powerful crushing jaws. They feed mainly on invertebrates including urchins and other echinoderms, mussels, clams, gastropods, crabs, spiny lobster, barnacles, squid, bryzoans, and polychaetes. Importantly, sheephead predation on urchins may act as an ecosystem driver by reducing and stabilizing urchin populations (Tegner & Dayton 1981) (Cowen 1983). Throughout their range, urchin populations can decrease kelp abundance, thereby altering the relative abundance of macroalgae in a kelp forest.

Level of protection: **Moderate-low**

Spotted sand bass (hook and line):

Direct impacts – Take of spotted sand bass (*Paralabrax maculatofasciatus*) by hook and line is unlikely to alter habitat as gear rarely touches the seafloor.

Spotted sand bass occur over sand or mud habitat in shallow bays, harbors, and coastal lagoons that contain eelgrass and surfgrass. Spotted sand bass are predominantly a warm water species and their distribution in the Southern California Bight is restricted to warm-water embayments. The movements of spotted sand bass are not well known, but tagging studies have shown that adults rarely range beyond the embayment where they settled as juveniles (Allen, unpublished data). Spotted sand bass form breeding aggregations just near the entrances of embayments between May and September (Allen et al 1995). One study in southern California showed that different populations of spotted sand bass display varied mating strategies (Hovey & Allen 2000), which further supports the conclusion that spotted sand bass are relatively sedentary and thus their abundance is likely to be altered by take relative to an SMR.

Indirect impacts – Spotted sand bass are important predators in coastal embayments, so removal of this species is likely to have impacts on community structure within an MPA. Spotted sand bass are carnivores and feed mainly on demersal invertebrates including clams, crabs, squid, and polychaetes.

Level of protection: **Moderate-low**

Spiny lobster (traps, hoop nets, or hand take by scuba):

Direct impacts – In the SCSR, spiny lobster (*Panulirus interruptus*) are taken using three main methods: recreational hand collection by scuba- or free-divers, recreational take using hoop nets, and commercial take using traps or pots. All three of these methods may cause some habitat disturbance (anchoring and placement of traps which can disturb rock and kelp habitat), but these habitat effects are unlikely to alter community structure significantly.

The movement habits of spiny lobster are not well known. Some reports indicate that adult lobster migrate offshore into deeper waters during the winter months (DFG 2001) but the distance and prevalence of this migration are not well documented. Recent studies have shown that the home range and habits of spiny lobster may vary markedly from site to site and may be related to predator abundance and habitat quality (Hovel & Lowe, in prep). A study conducted in a small MPA (0.6 sq mi) on Catalina Island where lobster take had been prohibited for 23 years showed that legal-sized lobsters were significantly more abundant inside the no-take area than in nearby fished areas (Iacchei 2005). This suggests that at least some portion of the lobster population is relatively sedentary and likely to benefit directly from MPAs within state waters. Thus the abundance of lobsters in an area that allows lobster fishing is likely to be lower than that in a no-take marine reserve.

Bycatch in the lobster fishery, while not well quantified, is likely low and unlikely to alter the abundance of any other species relative to an SMR. Anecdotal reports from the recreational hoop-net fishery indicate that sheephead, nearshore rockfish, sand bass, California scorpionfish, octopus, rock crab, sheep crab, miscellaneous invertebrates, sharks, skates, and rays make up the most common invaders of recreational hoop nets.

Indirect impacts – Lobsters are important predators in the nearshore rocky environment, therefore removal of this species is likely to have impacts on community structure within an MPA. Adult lobsters feed on a variety of algae and invertebrates including urchins, snails, mussels, and clams. Importantly, lobster predation on urchins may act as an important ecosystem driver by reducing and stabilizing urchin populations (Tegner & Levin 1983) (Lafferty 2004) (Behrens & Lafferty 2004). Throughout their range, urchin populations can impact (decrease) kelp abundance, thereby altering the relative abundance of macroalgae in a kelp forest.

Level of protection: **Moderate-low**

References for Chapter 3

Allen, L.G. unpublished data.

Allen, L. G., M. S. Love, and J. W. Smith. 1995. The life history of the spotted sand bass (Paralabrax maculatofasciatus) within the southern California bight. *CalCOFI Rep*. 36:193-203.

Baca Hovey, C., L. G. Allen, and T. E. Hovey. 2002. The reproductive pattern of barred sand bass (Paralabrax nebulifer) from southern California. *CalCOFI Rep*. 43:174-181.

Behrens, M. D., and K. D. Lafferty. 2004. Effects of marine reserves and urchin disease on southern Californian rocky reef communities. *Marine Ecology Progress Series* 279:129-139.

Boutillier, J. A., and J. A. Bond. 2000. Using a fixed escapement strategy to control recruitment overfishing in the shrimp trap fishery in British Columbia. *J. Northw. Atl. Fish Sci*. 27:261-271.

Boutillier, J.A. unpublished data.

Bower, S.M. and J.A. Boutillier. 1990. Sylon (Crustacea: Rhizocephala) infections on the shrimp in British Columbia. In: *Pathology in Marine Science*. S.O. Perkins and T.C. Cheng (eds.). Academic Press. p. 267-275

DFG (California Department of Fish and Game). 1982. *California Fish and Wildlife Plan. Volume II-Species Plans, Part C-Living Marine Resources*. Preliminary Draft. June 1982. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California, 95814.

DFG, 2001. *California's Living Marine Resources: A Status Report*. California Department of Fish and Game, December 2001.

Collyer, R. D., and P. H. Young. 1953. Progress report on a study of the kelp bass, Paralabrax clathratus. *Fish Bulletin* 39:191–208.

Cowen, R. K. 1983. The effect of sheephead (Semicossyphus pulcher) predation on red sea urchin (Strongylocentrotus franciscanus) populations: an experimental analysis. *Oecologia* 58:249-255.

Crandall, W. C., 1912. Fertilizer resources of the United States. Appendix N. The kelps of the southern California Coast. U.S. Senate Doc. 190. pp. 209–213.

Ebeling, A. W., Laur, D. R., Rowley, R. J. (1985). Severe storm disturbances and reversal of community structure in a southern California kelp forest. Mar. Biol. 84:287-294

Froeschke, J. T., L. G. Allen, and D. J. Pondella. 2006. The fish assemblages inside and outside of a temperate marine reserve in southern California. *Bull. Southern California Acad. Sci*. 105:128-142.

Gaida, I. H., D. G. Buth, S. D. Matthews, A. L. Snow, S. B. Luo, and S. Kutsuna. 2003. Allozymic variation and population structure of the California grunion, Leuresthes tenuis (Atheriniformes: Atherinopsidae). *Copeia* 2003: 594-600.

Graham MH (2004) Effects of local deforestation on the diversity and structure of Southern California giant kelp forest food webs. Ecosystems, 7, 341–357.

Graham MH, Halpern BS, Carr. MH 2008. Diversity and dynamics of California subtidal kelp forests. In: Food Webs and the Dynamics of Marine Reefs (McClanahan, T. and G.M. Branch, eds.), Oxford University Press, Oxford.

Harrold, C., Reed, D. C. (1985). Food availability, sea urchin grazing, and kelp forest community structure. Ecology 66:1160-1169

Harrold, C. and J.S. Pearse 1987. The ecological role of echinoderms in kelp forests. Pages 137-233 *In:* Jangoux, M. and J.M. Lawrence (eds) Echinoderm Studies, Volume 2. AA Balkema Publishers, VT, USA.

Hovey, T. E., and L. G. Allen. 2000. Reproductive patterns of six populations of the spotted sand bass, Paralabrax maculatofasciatus, from Southern and Baja California. *Copeia* 2000:459-468.

Iacchei, M., P. Robinson, et al. (2005). "Direct impacts of commercial and recreational fishing on spiny lobster, Panulirus interruptus, populations at Santa Catalina Island, California, United States." *New Zealand Journal of Marine and Freshwater Research* 39: 1201-1214.

Johnson, P. B., K. L. Martin, T. L. Vandergon, R. L. Honeycutt, R. S. Burton, and A. Fry. 2009. Microsatellite and Mitochondrial Genetic Comparisons Between Northern and Southern Populations of California Grunion Leuresthes tenuis. (*Copeia*, in press.)

K. Hovel and C. Lowe, in prep

Lafferty, K. D. 2004. Fishing for lobsters indirectly increases epidemics in sea urchins. *Ecological Applications* 14:1566-1573.

Lawrence, J. M. (1975). On the relationships between marine plants and seaweeds. *Oceanogr. Mar. Biol. Ann. Rev*. 13:213-286

Lowe, C. G., D. T. Topping, D. P. Cartamil, and Y. P. Papastamatiou. 2003. Movement patterns, home range, and habitat utilization of adult kelp bass Paralabrax clathratus in a temperate no-take marine reserve. *Marine Ecology Progress Series* 256:205-216.

Mason, T.J. 2008. *Home range size, habitat use, and the effects of habitat breaks on the movements of temperate reef gamefishes in a southern California marine protected area*. Master's Thesis. Department of Biological Sciences, California State University, Long Beach.

Quast, J. C. 1968. Observations on the food and biology of the kelp bass, Paralabrax clathratus with notes on its sportfishery at San Diego, California. *California Department of Fish and Game Fish Bulletin* 139:81–108.

Schroeter, S. C., D. C. Reed, D. J. Kushner, J. A. Estes, and D. S. Ono. 2001. The use of marine reserves in evaluating the dive fishery for the warty sea cucumber (Parastichopus parvimensis) in California, U.S.A. *Can. J. Fish. Aquat. Sci*. 58.

Tegner, M. J., and P. K. Dayton. 1981. Population Structure, Recruitment and Mortality of Two Sea Urchins (Strongylocentrotus franciscanus and S. purpuratus) in a Kelp Forest. *Marine Ecology Progress Series* 5:255-268.

Tegner, M.J. & Dayton, P.K. (1991) Sea urchins, El Niños, and the long-term stability of Southern California kelp forest communities. *Marine Ecology Progress Series* 77: 49–63.

Tegner, M., Levin, L., 1983. Spiny lobsters and sea urchins: analysis of a predator-prey interaction. *Journal of Experimental Marine Biology & Ecology* 73: 125-150.

Tetreault, I. and R. F. Ambrose (2007). "Temperate marine reserves enhance targeted but not untargeted fishes in multiple no-take MPAs." *Ecological Applications* 17(8): 2251-2267.

Tetreault, I., and R. F. Ambrose. 2007. Temperate marine reserves enhance targeted but not untargeted fishes in multiple no-take MPAs. *Ecological Applications* 17:2251-2267.

Topping, D. T., C. G. Lowe, and J. E. Caselle. 2005. Home range and habitat utilization of adult California sheephead, Semicossyphus pulcher (Labridae), in a temperate no-take marine reserve. *Marine Biology* 147:301-311.

Young, P. H. 1963. The kelp bass (Paralabrax clathratus) and its fishery, 1947–1958. *Fish Bulletin* 122:1–67.

4. Habitat Representation Analyses (Goals 1 and 4)

Status of this chapter: The SAT has approved of the habitats and evaluation methods in this chapter.

Identification of Key and Unique Habitats for the MLPA South Coast Study Region

The Marine Life Protection Act (MLPA) provides guidance that marine protected areas (MPAs) should encompass a variety of marine habitat types and communities, across a range of depths and environmental conditions. This chapter identifies the key and unique habitats in the South Coast Study Region, as required by the MLPA. The methods for evaluating MPA proposals with respect to representation of key and unique habitats are described in detail later in the chapter.

Habitats Identified in the MLPA and the Master Plan

Subsequent to provisions in the MLPA, the *Master Plan* further refines the list of “key” habitats (listed below). The SAT recognizes estuaries as a critical California coastal habitat; consequently, estuaries were added to the list of key habitats in the *Master Plan*. The *Master Plan* further subdivides habitats identified in the MLPA by substrate type or depth, identifying the following key habitats: sand beach, rocky intertidal, estuary, shallow sand, deep sand, shallow rock, deep rock, kelp, shallow canyon, and deep canyon. Because changes in species composition occur across depth zones, even over the same substratum, the SAT has subsequently refined the habitat definitions to include five depth zones (intertidal, intertidal to 30 meters (m), 30 m to 100 m, 100 m to 200 m, and deeper than 200 m). Key habitat types provide benefits by harboring a particular set of species or life stages, having special physical characteristics, or being used in ways that differ from other habitats. The SAT also recommends the representation in MPAs of oceanographic features that represent specific pelagic habitats, such as upwelling centers, estuary waters, river plumes, fronts, and retention zones.

Key habitats in the South Coast Region

The set of habitats described in the MLPA and *Master Plan* can be expanded or reduced by the SAT to reflect representative habitats for each study region. In addition to the habitat types delineated in the MLPA, the SAT notes that key habitat types such as rocky reefs, intertidal zones, and kelp forests are actually broad categories that include several types of habitat and that special consideration in design planning should be given to habitats that are uniquely productive (e.g. upwelling centers or kelp forests) or aggregative (e.g. fronts) or those that sustain distinct use patterns. All of the key habitats except sea mounts occur in the South Coast Study Region within state waters, although some, such as pinnacles, are not well mapped.

Considering guidance from the MLPA and *Master Plan*, the SAT has identified the following "key" marine habitats in the South Coast Study Region (m = meters):

- rocky shore
- sandy beach
- surfgrass
- coastal marsh
- tidal flats
- estuarine waters
- eelgrass
- kelp
- rocky reef 0-30m
- rocky reef 30-100m
- rocky reef 100-200m
- rocky reef >200m
- soft bottom 0-30m
- soft bottom 30-100m
- soft bottom 100-200m
- soft bottom >200m
- submarine canyons
- pinnacles
- upwelling centers
- retention zones
- river plumes
- fronts

Although underwater pinnacle and estuary habitats are considered to be key habitats, the SAT notes that Farnsworth Bank and San Diego Bay have unique characteristics that should be considered for protection by the SCRSG. Farnsworth Bank is a unique underwater pinnacle in 15 to 91 m (50 to 300 ft) of water off the seaward coast of Santa Catalina Island that supports rare dense growths of the purple hydrocoral (*Stylaster californica,* previously known as *Allopora californica*). Farnsworth Bank is currently a State Marine Conservation Area explicitly to prohibit take of purple coral. San Diego Bay is a large and ecologically important unique bay/estuary complex in the South Coast Study Region. Most of these key habitats are mapped in the *Draft Regional Profile of the South Coast Study Region*[14]

Kelp Forests and Seagrass Beds in the South Coast

Kelp forests and seagrass beds are biogenic key habitats in the study region which require additional comment. Kelp forest communities are known to be among the most productive and biologically rich habitats in the region. The dominant kelp species and their associated communities differ across bioregions, with substratum type, and with depth. For example, the elk kelp (*Pelagophycus porra*) grows over a narrow depth range (30 to 90 m) on coarse sediment-laden habitats (e.g. the leeward side of Santa Catalina Island) as well as rocky substrata (e.g Point Loma) and has a limited geographical distribution (Abbot and Hollenberg 1976). Giant kelp (*Macrocystis pyrifera*), the major species of most southern California kelp forests, is more widely distributed in the state and the study region where it grows over a broader depth range (6 to 80 m) and occurs on substrata ranging from hard to soft rock to coarse sand (Abbott & Hollenberg 1976). Seagrasses are flowering plants that form important habitat in shallow waters for a variety of marine organisms. The most common type of seagrass along the open coast is surfgrass (*Phyllospadix* spp.), which forms beds that fringe rocky coastline areas at the zero tide level down to several meters below the zero-tide level. Surfgrass serves as an important habitat for a variety of life stages of fish and invertebrates,

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[14] The South Coast Regional Profile can be found at (http://www.dfg.ca.gov/mlpa/index.asp)

including the California spiny lobster (Engle 1979) as well as algae (Stewart & Myers 1980). The most common type of seagrass in estuaries and sheltered coastal bays is eelgrass (*Zostera marina*), which also occurs along the open coast in the Channel Islands (Coyer et al 2008). A second species of eelgrass (*Zostera pacifica*) occurs along the open coast in southern California, on both the channel islands and the mainland[5]. The long leaves and dense, matted root systems of eelgrass beds help prevent erosion and maintain stability in nearshore areas by slowing down water flow; this consequently enhances sediment accumulation and faunal recruitment. Eelgrass beds also provide refuge, foraging, breeding, or nursery areas for invertebrates, fish, and birds (Hoffman 1986).

Pelagic Habitats in the South Coast Study Region

There are several key pelagic habitats, defined by water properties and water motion, that require additional comment:

(i) Estuary waters: Sheltered waters within semi-enclosed bays (e.g. San Diego Bay), seasonally closed lagoons (e.g. San Dieguito Lagoon), and harbors (e.g. Dana Point Harbor) are typically shallow and warm with low salinities after winter rains and relatively high turbidity and suspended particulate material year-round.

(ii) Upwelling centers: In areas where cold sub-thermocline water breaks the surface, it supplies nutrients to near-surface primary production. This upward flux of cold water includes upwelling, internal waves and vertical mixing across the thermocline. A plume of cold water flows away from the center, with increasing temperature and phytoplankton content. Recurrent upwelling sites are demarcated on the map, including the major upwelling center at Point Conception and smaller, less persistent sites at Point Dume, Palos Verdes, and Point Loma.

(iii) Retention zones: Warm and stratified waters are found in areas where there is an absence of upwelling and where there is some topographic shelter. Depending on nutrient supply and “age” of the water, the warm surface layer may be rich in phytoplankton (e.g. Santa Barbara Channel) or the phytoplankton maximum may be found sub-surface, on the thermocline (e.g. La Jolla Bay).

(iv) River plumes. During periods of river flow, plumes represent waters with low salinity, low stratification, and a high load of terrigeneous material (both biogenic and contaminants). While plumes occur infrequently in southern California, primary locations are listed in the water quality chapter, e.g. Santa Clara River plume off Ventura.

(v) Fronts. At the boundary between waters of different density (warm vs cool, salty vs less salty), there is a surface convergence that collects plankton, forming the foundation of rich feeding areas for fish, birds and mammals. Plume fronts are transient, while upwelling fronts are more persistent, as in the western Santa Barbara Channel.

Pelagic habitats, created by water movement, are necessarily fluid and difficult to demarcate with fixed boundaries. Furthermore, processes like upwelling and terrestrial runoff occur as events in response to winds or rainfall, so features are impermanent, although they may be recurrent. Thus, while it is important to recognize these habitats, they are difficult to map and evaluate for habitat representation and replication. For the purpose of evaluation, only estuary waters, upwelling centers and retention zones are mapped, since they are strongly associated with topography, such as bays or headlands. However, the extent of these features can only be estimated and their variability cannot be shown on the maps. These pelagic habitats overlay benthic habitats and should be a secondary consideration in MPA siting.

Unique Habitats in the South Coast Study Region

Goal 4 of the MLPA aims to protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value. In addition to the key habitats and habitat features discussed previously, two unique or rare habitat types occur in the South Coast Study Region and should be considered for inclusion in MPAs. These are *oil seeps* and *shallow hydrothermal vents.* The SAT will evaluate representation, but not replication of these two unique habitats, so consideration should be given for their inclusion in MPAs. Benthic communities and environmental conditions around oil seeps and shallow hydrothermal vents differ from those in surrounding areas. Natural oil seeps are not rare in the SCSR, though they occur nowhere else in state waters. The largest concentration of oil seeps occurs in the Santa Barbara Channel area (Wilkinson 1971). Shallow hydrogen sulfide vents appear to be restricted to White Point on the Palos Verdes Peninsula. These vents occur from the intertidal to shallow subtidal depths (0-10m) and support H_2S-oxidizing bacterial mats and have different localized water chemistry and temperature (Daley et al 1993). Recent research has found that the hydrothermal vent macroinvertebrate community at White Point is a subset of the surrounding fauna and is limited to species able to withstand stressful environments (Malwani & Kim 2008). The microbial biomass produced through sulfur oxidation around the vents is morphologically similar to deep hydrothermal vents and is an energy source based on chemosynthesis rather than photosynthesis (Dailey & Anderson 1991). Currently, little to no research has been conducted on the effects of extractive or non-extractive human activities on shallow hydrothermal vents or oil seep communities.

Summary of Guidelines and Evaluation Methods: Habitat Representation

The *Master Plan* guidelines with respect to habitat protection are as follows:

> 1: “For an objective of protecting the diversity of species that live in different habitats and those that move among different habitats over their lifetime, every ‘key’ marine habitat should be represented in the MPA network.”
>
> 2: “’Key’ marine habitats (defined above) should be replicated in multiple marine protected areas (MPAs) across large environmental and geographic gradients to protect the greater diversity of species and communities that occur across such gradients, and to protect species from local year-to-year fluctuations in larval production and recruitment.”

Guidance in the MLPA closely mirrors these guidelines in the *Master Plan* with one key difference: the MLPA specifically indicates that marine reserves (SMRs) are an important component of habitat protection.

To assess how the key and unique habitats defined here are represented across a range of environmental conditions, the SAT has identified five distinct bioregions within the MLPA South Coast Study Region (see Chapter 2). Because the key habitats within these bioregions support different marine life communities, the SAT recommends that MPA proposals represent key habitats across all five bioregions.

In evaluating habitat representation the SAT considers:

- the quality of habitat maps,
- the availability of habitats across the entire study region,
- the availability of habitats within the five bioregions defined by the SAT,
- the percentage of available habitat protected in MPAs across all six levels of protection, and
- the distribution of habitat protection across the five bioregions in the MLPA South Coast Study Region.

Several of the key and unique habitats named above have limited distribution in the study region or are poorly mapped (see below for more detailed discussion of habitat map quality). In consideration of data limitations, the SAT conducts a full evaluation of habitat representation (including area and percent of habitat protected) only for habitats that are adequately mapped. For habitats that are not comprehensively mapped, the SAT conducts one of the following simplified evaluations of habitat representation: 1) presence/absence of the habitat in an MPA proposal, or 2) the percent of known habitat point-locations protected.

The SAT is currently discussing projects that affect habitat quality such as habitat restoration and artificial reefs and considering if or how these should be included in habitat representation analyses.

Consideration of Habitat Map Quality

The quality of habitat mapping influences the way in which habitat representation can be assessed. For habitats that are comprehensively mapped, it is possible to accurately assess both the amount of habitat encompassed by a proposed MPA and the percent of available habitat protected. Unfortunately, many of the habitat maps are subject to one or more of the following limitations: 1) mapping is not of consistent quality across the entire study region, 2) mapped data does not allow assessment of the extent of habitat protected (aerial or linear extent), or 3) mapping does not accurately reflect presence or absence of habitats.

Table 4-1 summarizes the limitations of habitat maps and recommendations for use of habitat data in habitat evaluations.

Table 4-1. Habitat Mapping Quality

Note: Table will be completed as data are reviewed.

Habitat	Source	Reviewed By	Review Summary	Recommended Use
Key Habitats				
rocky shore	NOAA Environmental Sensitivity Index (ESI) shoreline			
sandy beach	NOAA ESI shoreline			
surfgrass	Minerals Management Service (MMS) 1980-1982			
coastal marsh	NOAA Coastal Change Assessment Program (CCAP)	R. Ambrose	1) may under-estimate the extent of marsh in some areas 2) no major gaps in coverage	appropriate for assessing area and percent protected
tidal flats	NOAA ESI shoreline			
estuaries	US Fish and Wildlife Service National Wetland Survey, NOAA ESI (2004)			
eelgrass - estuarine	The Nature Conservancy, Humboldt Atlas, DFG, and NOAA (2004)			

Habitat	Source	Reviewed By	Review Summary	Recommended Use
eelgrass – open coast	Engle and Miller 2005, Jessie Altstatt, Santa Barbara Channel Keepers			
kelp – giant kelp	DFG			
kelp – elk kelp	K. Miller, J. Engle, P. Dayton, E. Parnell, DFG ROV data			
rocky reef 0-30m	CSUMB Seafloor mapping			
rocky reef 30-100m	CSUMB Seafloor mapping			
rocky reef 100-200m	CSUMB Seafloor mapping			
rocky reef >200m	CSUMB Seafloor mapping			
soft bottom 0-30m	CSUMB Seafloor mapping			
soft bottom 30-100m	CSUMB Seafloor mapping			
soft bottom 100-200m	CSUMB Seafloor mapping			
soft bottom >200m	CSUMB Seafloor mapping			
submarine canyons	G. Green			
pinnacles	unmapped?			

Habitat	Source	Reviewed By	Review Summary	Recommended Use
upwelling centers	J. Largier			
retention areas	J. Largier			
river plumes	unmapped			
oceanographic fronts	unmapped			
Unique Habitats				
oil seeps	USGS			
shallow hydrothermal vents	A. Melwani			

Habitats with linear measurements include sandy or gravel beaches, rocky intertidal, coastal marsh, tidal flats, and surfgrass. Habitats with area measurements include estuaries, coastal marsh, eelgrass, kelp, and hard and soft bottom at depths of 0-30 m, 30-100 m, 100-200 m, and greater than 200 m. Due to a lack of nearshore substrate data, shallow hard- and soft-bottom habitats were also estimated as linear measurements by determining the type of habitat present along a 20 meter depth contour.

Although aerial measurements of kelp were available from DFG surveys, a linear proxy of kelp extent was used for all habitat analyses. Because kelp forest communities vary markedly by depth, the SAT determined that the most important consideration in protection of a kelp forest community is that the MPA extends across depth range of the kelp forest. Simply stated, a narrow band of kelp along a steep shore is likely to encompass as much biological richness as a broader kelp bed along a gently sloping shore, provided that the two extend along a similar length of shoreline. To ensure that both steep and gently sloping kelp beds are considered equally in habitat representation and replication analyses, the SAT used kelp bed length as the measure of kelp habitat. Kelp bed length was measured with a line drawn along the outside of the kelp bed, roughly parallel to the shore and derived from the composite aerial extent of kelp in the years 1989, 1999, and 2003 through 2006.

References for Chapter 4

Abbott, I. A. and G. J.Hollenberg (1976) *Marine algae of California*. Stanford Univ. Press, Stanford, CA.

Coyer, J. A., K. A. Miller, J. M. Engle, J. Veldsink, A. Cabello-Pasini, W. T. Stam, and J. L. Olsen. 2008. Eelgrass meadows in the California channel islands and adjacent coast reveal a mosaic of two species, evidence for introgression and variable clonality. *Annals of Botany*:73-87.

Dailey, M. D., D. J. Reish, and J.W. Anderson. 1993. *Ecology of the Southern California Bight.* University of California Press, Berkeley, California, USA.

Engle, J. M. 1979. *Ecology and growth of juvenile California spiny lobster, Panulirus interruptus (Randall)*. Ph.D. Dissertation, University of Southern California.

Hoffman, R. F. 1986. Fishery utilization of eelgrass (Zostera marina) beds and non-vegetated shallow water areas in San Diego Bay. National Marine Fishery Service, Southwest Region. *Administrative Report* SWR-86-4.

Melwani, A.R. and S.L. Kim. 2008 Benthic infaunal distributions in shallow hydrothermal vent sediments. *ACTA Oecologica*. 33: 162-175.

Stewart, J. G. and B. Myers (1980) Assemblages of algae and invertebrates in Southern California Phyllospadix-dominated intertidal habitats. *Aquatic Botany* 9:73-94.

Wilkinson, E.R., 1971, California offshore oil and gas seeps; in *California oil fields – summary of operations*; California Div. of Oil and Gas; v. 57, n. 1, p. 5-28.

5. Habitat Replication Analyses (Goals 1, 2, 3, 4 and 6)

Status of this chapter: The SAT has approved of the evaluation methods in this chapter.

The MLPA's Guidelines Regarding Habitat Replication Analyses

The *Master Plan* guidelines with respect to habitat replication are as follows:

1. "Key" marine habitats (defined above in Chapter 4.0) should be replicated in multiple marine protected areas (MPAs) across large environmental and geographic gradients to protect the greater diversity of species and communities that occur across such gradients, and to protect species from local year-to-year fluctuations in larval production and recruitment.

2. For an objective of providing analytical power for management comparisons and to buffer against catastrophic loss of an MPA, at least three to five replicate MPAs should be designed for each habitat type within a biogeographical region [Point Conception to U.S./Mexico border].

Replication of habitats in MPAs addresses goals 1, 2, 3, 4 and 6 of the Marine Life Protection Act (MLPA) as well as other requirements and guidance in the act, including habitat replication within state marine reserves (SMRs). Evaluations of habitat replication include the number of replicates in SMRs, and also the replication of habitats in state marine conservation areas and state marine parks at the various levels of protection.

Guidance in the *Master Plan* requires that habitat be replicated in three to five MPAs in the biogeographic region. However, spacing guidelines (see Chapter 7.0) may require greater replication of habitats. Benefits of MPAs are largely dependent on the habitat contained in them. An MPA that does not contain appropriate habitat for an ecosystem or particular species (e.g. kelp forest) provides insufficient benefits to that ecosystem or species.

In evaluating habitat replication, the SAT considers:

- The overall size of each MPA or cluster of MPAs (contiguous MPAs with different allowed uses) at the three highest levels of protection, and
- the extent of each habitat contained within the MPA or MPA cluster.

Only MPA clusters above the minimum size (nine square miles[15]) were considered for habitat replication (with the exception of estuarine habitats). The SAT considered an MPA to include a specific habitat if the MPA encompassed a critical amount of the habitat. This critical amount

[15] Unless otherwise noted, all distance measurements are measured in statute miles and all area measurements are measured in square statute miles. Depths are reported in meters (m).

was defined as an area sufficient to encompass 90% of the species known to use the habitat in sufficient abundance to be ecologically represented in the habitat. (see Table 5-1)

To determine the estimated amount of habitat needed, the SAT examined biological survey data from a variety of habitat types present in the study region. Only datasets that had the following features were used: (1) sampling allowed for estimation of species richness, (2) sampling was spatially explicit (the location, depth and area were known), (3) sufficient replication to allow for robust resampling, (4) asymptotic like area by richness curves), (5) absence of meaningful design bias, such as would exist if only certain taxa were targeted. Using a resampling procedure and accumulation functions (including Michaelis-Menten) the SAT then estimated the amount of habitat area needed to encompass 90% of the species likely to occur in each habitat (see Figure 5-1).

Figure 5-1. Estimated Proportion of Species per Amount of Habitat for Rocky Habitats

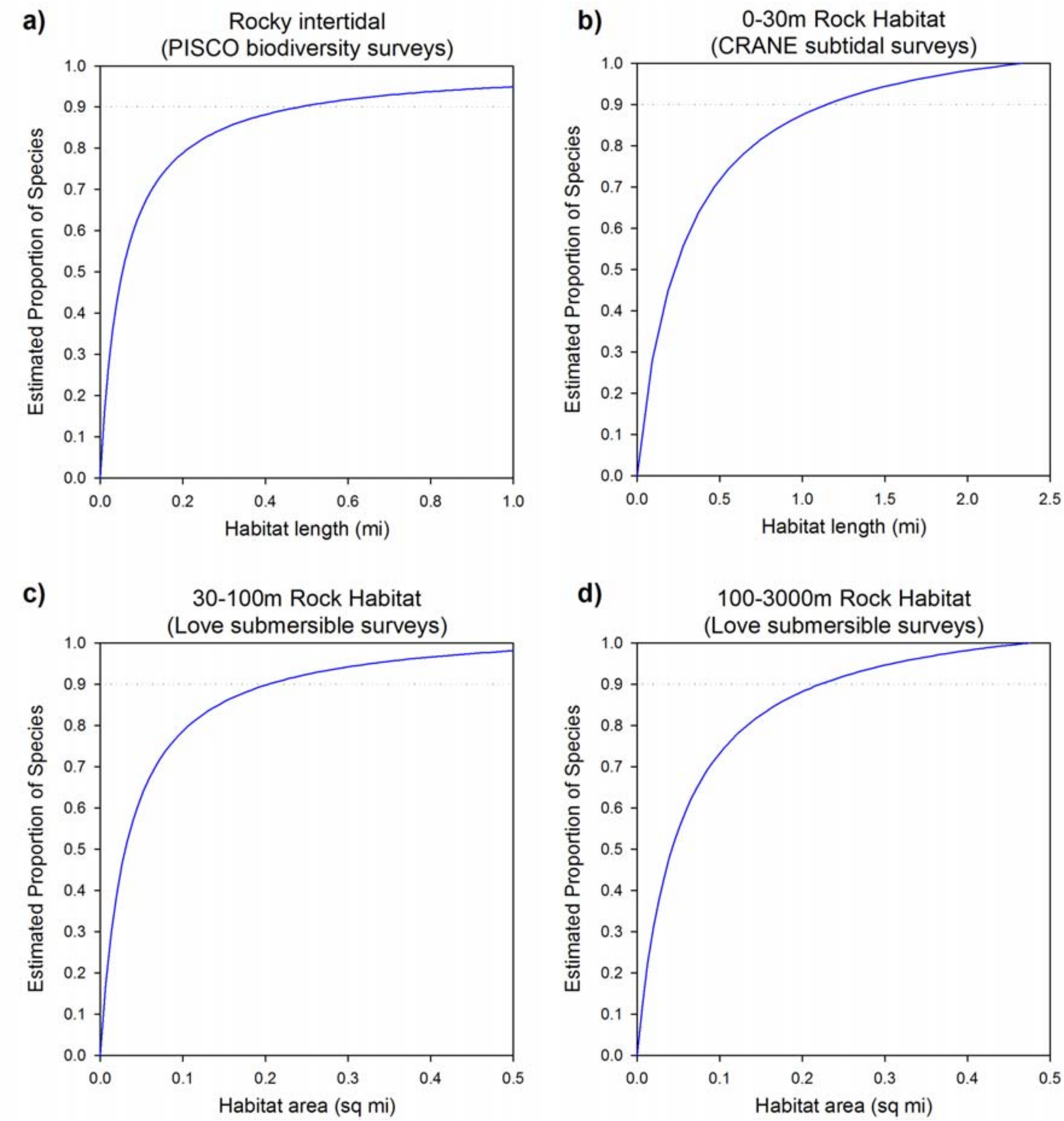

Table 5-1. Amount of Habitat in an MPA Necessary to Encompass 90% of Local Biodiversity Given in Linear Statute Miles and Square Statute Miles

Habitat	Representation needed to encompass 90% of biodiversity	Data Source
Rocky Intertidal	~0.48 linear miles	PISCO Biodiversity
Shallow Rocky Reefs/Kelp Forests (0-30 m)	~1.14 linear miles	CRANE Subtidal Surveys
Deep Rocky Reefs (30-100 m)	~0.20 square miles	Love Surveys
Deep Rocky Reefs (100-3000 m)	~0.22 square miles	Love Surveys
Sandy Beaches *	~1.14 linear miles	See below
Soft-Bottom Habitat (0-30 m)	~1.14 linear miles	See below
Soft-Bottom Habitat (30-100 m)	~2.24 square miles	SCCWRP (BIGHT '98 & '03)
Soft-Bottom Habitat (100-200 m)	~1.10 square miles	SCCWRP (BIGHT '98 & '03)
Soft-Bottom Habitat (>200 m)	~0.46 square miles	SCCWRP (BIGHT '98 & '03)
All Soft-Bottom Habitat (>0 meters)	***~8 square miles***	***Preferred option - see below***
Estuarine Habitats	0.12 square miles (77 acres)	SONGS sampling

* Sandy beaches are often linked to shallow soft-bottom areas, therefore linear extent for sandy beaches is tied to linear extent of soft-bottom habitat, see below for further explanation.

For kelp forest, shallow soft-bottom, and shallow rocky habitats, protection of habitat must extend from shore to the 30 meter contour.

As noted above, estuaries are not included in the general rule that replication of habitat needs to be within an MPA cluster that is at least nine square miles. This is because estuarine habitats very often are not adjacent to coastal rocky habitats and a requirement for co-location could greatly restrict the location of MPA clusters.

The SAT recommends that wherever possible, a mixture of estuarine sub-habitats be protected in close proximity to one another to allow for the movement of species among sub-habitats. Additionally, protection of areas close to the mouth of an estuary is likely to have great benefit for species that use both estuarine and open-coast habitats. As for all other habitats shown above, the minimum area for estuarine reserves were based upon biological surveys and yielded the estimated amount of area needed to encompass 90% of the biodiversity in an estuarine system. The analysis showed that 77 acres is sufficient area to capture 90% of the species across the three main estuarine sub-habitats: eelgrass, tidal flats, and coastal marsh. In order for estuarine habitats to be considered present, a minimum of 77 acres of estuarine habitats must be included within an MPA. For the three sub-habitats to be considered present, a minimum of 25 acres of each must be included within an MPA.

There were several representative habitat types for which survey data was either unavailable or there was insufficient replication to use the methodology discussed above. The presence of these habitats in a given MPA was assessed as follows:

Soft bottom (0-30 meters): The species that are unique to this habitat mainly inhabit the surf zone; therefore the linear extent of shallow soft bottom was used to assess the presence of this habitat. The distribution and movement patterns of species in the surf zone is likely similar to that of species on shallow rocky reefs; therefore the percentage of biodiversity was assessed using the area/biodiversity relationship derived from 0-30m rocky reefs (1.14 linear mile = 90% biodiversity). To be considered present this habitat must also extend to the 30 meter contour.

Sandy beaches: No data were available to make a scientific assessment of the relationship between beach length and biodiversity. Because sandy beaches are usually inshore from shallow soft-bottom areas, and to make area delineation logistically feasible, the SAT linked the required linear extent of sandy beaches to soft-bottom habitats (0-30 meter). Hence, the SAT considered sandy beach habitat present if a given MPA included at least 1.14 miles of sandy beach.

All soft-bottom habitat (>0 meters): – A value of approximately eight square miles that includes all subtidal soft bottom habitat is preferred. This value comes from examination of two sets of National Marine Fisheries Service (NMFS) trawl data that yield a value of approximately eight square miles using the methodology discussed above. The NMFS samples come from areas just outside the region and are much larger than the Southern California Coastal Water Research Project (SCCWRP) samples (>10 times as large). Also the NMFS trawls were used for the MLPA North Central Coast Study Region evaluations which yielded a value of nine square miles of sandy habitat for that region. Hence, to integrate both the SCCWRP data and the results of analysis using NMFS data, we present a minimum and preferred size for sandy habitats. It is important to note that using the preferred size does not discard the values generated by the SCCWRP analysis; instead the two results should be used together. That is, the preferred size for soft bottom subtidal habitats is eight square miles including a shore length of at least 1.14 linear miles (for the 0-30 meter depth), and 2.24, 1.1 and 0.46 square miles of habitat in the 30-100, 100-200 and >200 meter zones, respectively.

6. Size (Goals 2 and 6)

Status of this chapter: The SAT has approved of the evaluation methods in this chapter.

The MLPA's Guidelines Regarding Size Analyses

Size guidelines were developed to provide for the persistence of important bottom-dwelling fish and invertebrate groups within marine protected areas (MPAs) (MLPA goals 2 and 6).

Guidance on size found in the *Master Plan* states:

> "For an objective of protecting adult populations, based on adult neighborhood sizes and movement patterns. MPAs should have an alongshore span of five to ten kilometers (3-6 miles or 2.5-5.4 nautical miles) of coastline, and preferably 10-20 kilometers (6-12.5 miles or 5.4-11 nautical miles). Larger MPAs would be required to fully protect marine birds, mammals and migratory fish."
>
> "For an objective of protecting the diversity of species that live at different depths and to accommodate the movement of individuals to and from shallow nursery or spawning grounds to adult habitats offshore, MPAs should extend from the intertidal zone to deep waters offshore."

The first size guideline arises primarily from data on the movement of adult and juvenile fish and invertebrates. Since MPAs will be most effective if they are substantially larger than the distance that individuals move, larger MPAs provide benefit to a wider diversity of species.

A summary of existing scientific studies of adult movement shows that adult movement varies greatly among California's marine species (Table 6-1). A recent synthesis and analysis of movement information for west coast rocky reef fishes indicates that the range of movement for 75 percent of individuals of a species (the 75th percentile movement range) was three kilometers (km) or less for 85% of the 26 species for which data are available[16]. However, the majority of movement data are available for shallow dwelling reef fishes (depth < 30-50 meters). This synthesis also shows that movement distance was not correlated with days at liberty for eleven species for which data are available, indicating that movement of these species was unlikely a diffusive process (i.e. increasing range with time). The analysis also showed that movement distances for deeper dwelling species (n= 6, 75th percentile = 35 km) were significantly greater than for shallower dwelling species (n= 18, 75th percentile = 2 km).

Therefore the choice of any MPA size determines the subset of species that could potentially benefit. For species with average movement distances of 100s to 1000s of miles, MPAs are unlikely to be a source of significant protection (except when they protect critical locations, e.g. spawning or nesting grounds). As a result, the *Master Plan* guidelines focus on species in the

[16] Jan Freiwald, unpublished dissertation.

first three movement categories in Table 4. The minimum size guideline of five to 10 km (3-6 miles) targets species in the first two categories. The preferable size range of 10 to 20 km (6-12.5 miles) attempts to provide substantially more benefit to the important group of species in category three (10 - 100 km movement). This group includes a number of important rockfishes from the California coast. Therefore, MPAs that meet the preferable size guideline should protect more biological diversity than MPAs that just meet the less stringent minimum guideline.

Table 6-1. Scales of Adult Movement for California Coastal Marine Species

0-1 km	1-10 km	10-100 km	100-1000 km	>1000 km
Invertebrates: abalone, mussel, octopus, sea star, snail, urchin		**Invertebrates**: Dungeness crab**		**Invertebrates**: jumbo squid**
Rockfishes: black & yellow, brown, copper, gopher, grass*, kelp, quillback, starry, treefish, vermilion	**Rockfishes**: black, China, greenspotted*, olive, yelloweye	**Rockfishes**: blue, bocaccio, yellowtail	**Rockfishes**: canary	
Other Fishes: cabezon, eels, greenlings, giant seabass, black, striped and pile perch, pricklebacks	**Other Fishes:** walleye perch*	**Other Fishes:** California halibut, lingcod, starry flounder	**Other Fishes:** anchovy, big skate, herring, Pacific halibut, sablefish**, salmonids**, sole, sturgeon	**Other Fishes:** sardine, shark**, tunas**, whiting**
				Reptiles: turtles**
		Birds: gulls, cormorants	**Birds:** gulls**	**Birds:** albatross**, pelican**, shearwater**, shorebirds**,terns**
		Mammals: harbor seal, otter	**Mammals:** porpoise, sea lion**	**Mammals:** dolphins, sea lion**, whales**

*Studies of this species included fewer than 10 individuals

**Seasonal migration

The second size guideline arises from an attempt to connect habitats across depth ranges. Many marine species spend different parts of their life cycle in different habitats that often span a range of depths; if these different habitats are connected in a single MPA, species that move among contiguous habitats will likely benefit.

Therefore, *the second size guideline states:* “For an objective of protecting the diversity of species that live at different depths and to accommodate the movement of individuals to and from shallow nursery or spawning grounds to adult habitats offshore, MPAs should extend from the intertidal zone to deep waters offshore.”

This guideline reflects the recommendation of the SAT that MPAs extend from the shore to the boundary of state waters (3 nautical miles). Extending MPA boundaries to the edge of state waters has the added benefit of allowing for connections with any potential future MPA designations in federal waters. The combination of the two size guidelines forms the basis for SAT evaluation of MPAs.

In evaluating the size of MPAs, the SAT considers both the area of the individual MPAs and clusters of contiguous MPAs. The size guidelines in the *Master Plan* specify that MPAs should cover an alongshore span of at least three to six statute miles (preferably six to 12 statute miles) and extend from the coast to deep waters offshore. Because state waters extend only three nautical miles (3.45 statute miles) offshore, the SAT considers an MPA or cluster of MPAs that extend to the offshore limit of state waters to meet the offshore guideline. The SAT combines and simplifies alongshore and offshore guidelines from the *Master Plan* by using a minimum size threshold of nine square statute miles, while recognizing that the state waters extend three nautical miles offshore rather than three statute miles as used in the area calculations. No MPA that is smaller than nine square miles could meet both the alongshore and onshore-offshore size guidelines mentioned above. Thus, for the purpose of SAT analyses, MPA clusters with areas nine to 18 square miles are considered to fall within the minimum size range, and those 18 to 36 square miles fall within the preferred size range. The guidelines for minimum and preferred areas of proposed MPAs will receive priority above the individual guidelines for alongshore and offshore spans. Additionally, the SAT recommends consideration of the configuration of proposed MPAs. Configurations with maximum area-to-perimeter ratios (e.g. 3 x 3 statute miles) are more likely to achieve greater protection for a variety of adjacent habitats and associated species than particularly narrow or long MPAs (e.g.1 x 9 statute miles).

In evaluating the size of MPAs, the SAT:

- combines contiguous MPAs at or above a given level of protection into “MPA clusters,” with size analyses conducted at three different levels of protection: “moderate-high,” “high,” and “very high”; and
- tabulates the number of MPA clusters in each size range (below minimum, minimum size range, preferred size range).

Note that estuarine MPAs are not evaluated with respect to size. Because species and life stages that inhabit estuaries rarely stray from the favorable estuarine habitat, the overall size of the MPA is less important than protecting the entire estuarine system. Thus, the SAT recommends that MPAs encompass entire estuaries, if feasible, but does not evaluate the size of estuarine MPAs relative to the size guidelines.

7. Spacing (Goals 2 and 6)

Status of this chapter: The SAT has approved of the evaluation methods in this chapter.

Spacing guidelines were developed to provide for the dispersal of important bottom-dwelling fish and invertebrate groups between marine protected areas (MPAs) and to promote connectivity in the network (Goals 2 and 6 of the Marine Life Protection Act; MLPA).

Connectivity in the MLPA South Coast Study Region

Connectivity throughout southern California was evaluated using known life history characteristics of fish and invertebrate larvae in conjunction with models of potential movement[17]. The model used to predict connectivity is based on realistic Regional Ocean Modeling System (ROMS) simulations. The model assumes larvae and young behave as Lagrangian particles transported through ocean circulation. The ROMS simulations of ocean circulation are driven by realistic winds and currents at lateral open boundaries (Conil & Hall 2006) (Dong & McWilliams 2007). The lateral-boundary conditions are derived from Simple Ocean Data Assimilation (SODA) (Carlton & Cao 2000) (Carlton et al 2000), while the wind field is calculated from the Fifth-Generation Pennsylvania State University-National Center for Atmospheric Research Mesoscale Model (MM5) (Hughes et al 2008). The circulation model is based on data gathered during the period of 1996–2003, including a strong El Niño and La Niña event.

ROMS simulations were validated through a series of comparisons with other types of data (Dong et al. In review), including data from the National Data Buoy Center's Acoustic Doppler Current Profilers (ADCP), high frequency radar, California Cooperative Oceanic Fisheries Investigations (CalCOFI), and Advanced Very High Resolution Radiometer (AVHRR). The mean ocean circulation and variations based on ROMS simulations show high levels of agreement with other types of observations. ROMS has limited ability to predict small-scale water movement near shore, which may contribute to local retention of larvae. As a consequence, the model likely underestimates self-replenishment.

Ocean circulation in southern California is dominated by the California Countercurrent, which moves water toward the mainland and north through the Southern California Bight, toward the Channel Islands, while the California Current moves water southward and offshore of the Channel Islands (Dever et al 1998). The northward flow along the mainland tends to be strengthened during the winter and during El Niño events. A counterclockwise gyre tends to form in the Santa Barbara Channel as water moves west along the mainland and eastward along the north side of the Channel Islands. The mean flow is less important in this region.

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[17] Researchers are S. Mitarai, D. Siegel, J. Watson of University of California, Santa Barbara and C. Dong & J. McWilliams of University of California, Los Angeles.

Modelers used ocean circulation from the ROMS simulation together with known life history characteristics of representative fishes and invertebrates (Table 7-1) to predict expected dispersal patterns throughout southern California. The modelers created “dispersal kernels” or expected dispersal by simulating the release of approximately a million particles from each location throughout southern California. Particles, which simulate larvae, were released in suitable habitats during the appropriate spawning period and for the period of larval duration for all representative species. Modelers explored the full range of potential movement based on release of particles every one kilometer throughout the study region and every six hours for a period of January 1, 1996 through December 31, 2002, including a strong El Niño and La Niña. Particles were passively transported by the simulated currents, and limited behavior (e.g. maintaining depth at a convergent front or edge of an eddy) was incorporated in the model. For each representative species, the model calculated numbers and locations of particles (or model larvae) reaching suitable habitat for settlement and growth at the end of their period of larval duration.

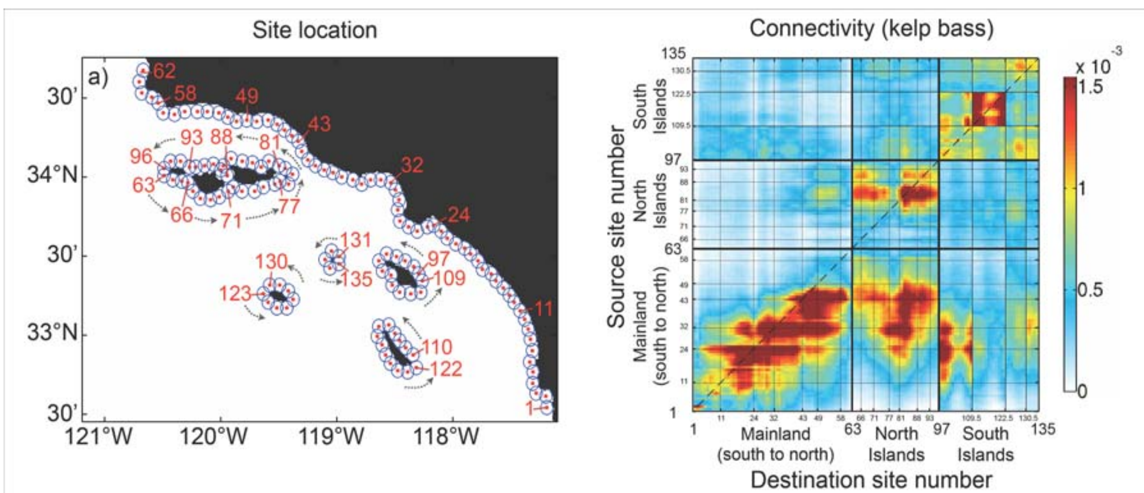
Table 7-1: Life History Characteristics of Representative Fish and Invertebrates

Species	Common Name	Spawning Season	Larval Duration
Paralabrax clathratus	Kelp bass	Apr-Nov (peak is May-Sep)	25-33 days
Paralabrax nebulifer	Barred sand bass	Jul-Aug	24-28 days
Semicossyphus pulcher	California sheephead	Jul-Oct	34-78 (median is 37)
Scorpaena guttata	California scorpionfish	May-Sep	30-60 days
Sebastes atrovirens	Kelp rockfish	Mar-Apr	50-75 days
Girella nigricans	Opaleye	Jun-Jul	
Caulolatilus princeps	Ocean whitefish	Jun-Aug	~90 days
Strongylocentrotus franciscanus	Red sea urchin	Dec-Feb	40-60 days
Lottia gigantea	Owl limpet	To be updated	To be updated
Kelletia kelletti	Kellet’s whelk	To be updated	To be updated
Embiotoca jacksoni	Black perch	Apr-Jun	livebearer, no pelagic larvae

Lagrangian particles representing larvae spread out across the entire Southern California Bight within about 30 days. The model results suggest that connectivity in southern California is heterogeneous and asymmetric reflecting the variable flow features in the southern California Bight. Although connections tend to be stronger within bioregions, there is some connectivity between bioregions. In other words, bioregions may be influenced to some extent by movement of animals, nutrients, pollutants, etc., which may be transported from adjacent regions. General patterns that emerge from modeling are strong poleward transport of particles along the mainland and some retention of particles in the Santa Barbara Channel and near San Clemente Island. For the representative species modeled, there is some connectivity between Santa Catalina and San Clemente islands, while there is more limited connectivity between San Nicolas Island and the other Channel Islands.

Connectivity is different for different species. For species with short larval duration, the mainland and islands tend not to be strongly connected. For species with longer larval duration, there is a stronger connection from mainland to islands, but the connection in the opposite direction tends to be weaker. The model predicts that northwestern and southeastern islands tend not to be strongly connected, except for representative species with longer larval duration, such as cabezon and kelp rockfish. Although San Nicolas Island is more isolated than the other Channel Islands, models predict some exchange of larvae between San Nicolas, Santa Catalina and San Clemente for species characteristic of the warm temperate waters and exchange of larvae between San Nicolas and the northwestern Channel Islands (San Miguel and Santa Rosa) for species characteristic of the cooler California Current. Dispersal patterns are strongly influenced by seasons and interannual variation. Ocean circulation and resulting movement of particles respond to dominant wind patterns and are not the same from season to season or year to year (although there are underlying patterns).

Figure 7-1. Connectivity of Sites in Southern California for Kelp Bass



Site location (left) describes the locations of release points for Lagrangian particles representing larvae. Mainland sites are labeled 0-62; northern Channel Islands sites (including San Miguel, Santa Rosa, Santa Cruz and Anacapa) are labeled 63-96; southern Channel Islands sites (including San Nicolas, Santa Barbara, Santa Catalina and San Clemente) labeled 97-135. Note that the grouping of these islands for the purpose of modeling connectivity is intended to simplify interpretation of results on graphics and does not reflect differences between bioregions. The connectivity matrix (right) represents the number of Lagrangian particles representing kelp bass larvae that are released from a particular source site (y axis) and arrive at a particular destination site (x axis). Red points indicate strong connections between sources and destinations, while blue points represent limited or no connections. For kelp bass, mainland sources are strongly connected to other mainland and island destinations, particularly the northern Channel Islands and Santa Catalina Island. However, island sources tend to be more isolated and are not as strongly connected to other island groups or mainland destinations.

Collectively, the larval dispersal kernels from the ROMS simulations provide a framework for understanding how different parts of the Southern California Bight are connected. The model results suggest that the mainland coast of southern California is an important source of larvae for the entire Southern California Bight and movement of larvae along the mainland coast is similar to that in other regions of California. The model results suggest that movement of larvae is more limited from the Channel Islands to the mainland and between the islands. As a consequence, spacing of MPAs at the Channel Islands must be evaluated differently from other regions of California.

Design of MPAs Along the Mainland Coast

Guidance on spacing of adjacent MPAs along the mainland coast, excerpted from the *Master Plan*, is:

> "For an objective of facilitating dispersal of important bottom-dwelling fish and invertebrate groups among MPAs, based on currently known scales of larval dispersal, MPAs should be placed within 50-100 kilometers (31- 62 miles or 27- 54 nautical miles) of each other."
>
> Neighboring MPAs placed closer than 50 km (31 miles) apart also meet the guideline for spacing for the goal of designing a network of MPAs.

This guideline arises from a number of studies that examine the persistence of marine populations with a network of marine reserves[18,] and its connection to larval dispersal. The spacing distances arise from a number of recent syntheses of data on larval dispersal in marine fish, invertebrates and seaweeds[19] and advances in modeling of larval transport (Siegel et al 2003) (Cowan et al 2006). As with adult movement, scales of larval movement vary enormously among species (meters to hundreds of kilometers). In contrast to adult movement, however, short-distance dispersers pose the biggest challenge for connections between MPAs.

Since the spacing guidelines are intended to help ensure connectivity between marine life populations, and populations only occur in suitable habitat, spacing analyses must consider the habitats encompassed by each MPA. Thus, the SAT conducts a separate spacing analysis for each key habitat (Chapter 4). Only MPAs that meet the minimum size guidelines (Chapter 6) and contain at least the critical extent of a habitat (Chapter 5) are counted as replicates of that habitat. The spacing analysis is conducted by measuring the distance between "replicate" MPAs or MPA clusters for each key habitat. Additionally, the spacing analysis is conducted for the three highest levels of protection afforded by MPAs: at least "moderate-high" protection; at least "high" protection; and, only MPAs with "very high" levels of protection.

To summarize the evaluation of MPA spacing along the mainland coast, the SAT:

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[18] (Botsford et al 2001) (Gaines et al 2003) (Gaylord et al 2005)

[19] (Shanks et al 2003) (Kinlan et al 2003) (Kinlan et al 2005)

- tabulates the maximum gaps between MPAs or MPA clusters along the mainland coast in relation to the SAT spacing guidelines of 31-62 statute miles,
- considers spacing for each key habitat separately,
- considers only MPAs or MPA clusters that are of sufficient size to contain adult movement ranges,
- considers only MPAs or MPA clusters that include a sufficient extent of habitat to be counted as meaningful biological replicates, and
- considers only MPAs or MPA clusters that have the three highest levels of protection.

Design of MPAs at the Channel Islands

Because of the complex geography and circulation in the Channel Islands region, the SAT recommends that spacing between adjacent MPAs on offshore islands is not an initial criterion for design. SAT guidelines for bioregions (Chapter 2), representative habitats (Chapter 4), including retention areas, and replication of habitats (Chapter 5) should be used as a starting point to design a network of MPAs for the Channel Islands region. Specifically, the SAT recommends establishing MPAs in each bioregion encompassing all representative habitats.

At the Channel Islands, three bioregions were identified based on ecological differences: (1) San Miguel, Santa Rosa, San Nicolas islands and the mainland coast at Point Conception, (2) Santa Cruz, Anacapa and Santa Barbara islands and (3) Santa Catalina and San Clemente islands (Chapter 2). The SAT tabulates the number and size of MPAs proposed in each bioregion. As noted above, only MPAs that meet minimum size guidelines (Chapter 6.0) and contain at least the critical extent of a habitat (Chapter 5.0), are counted as replicates of that habitat. Consistent with the evaluation of MPAs proposed along the mainland coast, the analysis is conducted for the three highest levels of protection afforded by MPAs: at least "moderate-high" protection; at least "high" protection; and, only MPAs with "very high" levels of protection.

To summarize the evaluation of MPA design at the Channel Islands, the SAT:

- considers the extent and level of protection afforded to each bioregion,
- considers only MPAs or MPA clusters that are of sufficient size to contain adult movement ranges,
- considers extent of key and unique habitats protected within proposed MPAs,
- considers only MPAs or MPA clusters that include a sufficient extent of habitat to be counted as meaningful biological replicates, and
- considers only MPAs or MPA clusters that have the three highest levels of protection.

Integrated Evaluation of Alternative MPA Proposals

The SAT will use spatially explicit models to evaluate contributions of proposed MPAs to conservation value (biomass or population persistence) and economic value (fishery catch or profit; Chapter 8 – Bioeconomic Modeling). Evaluations using models incorporate the actual size and spacing of alternative MPA proposals without imposing minimum thresholds levels for these characteristics. The models integrate spatial data on habitat, fishery effort, and proposed MPA locations and regulations and ultimately predict spatial distributions of fish abundances, fishery yields, and (for one model) fishery profits generated for each proposed network of MPAs.

To summarize the SAT evaluation of proposed MPAs using spatially explicit population models, the models can:

- integrate spatial data on habitat, fishery effort, and proposed MPA locations and regulations;
- consider potential contributions of proposed MPAs, regardless of size or spacing;
- consider potential impacts of allowed uses in proposed MPAs, regardless of the level of protection;
- predict biomass and larval supply (a proxy measure of population sustainability) for about 10 representative species, across space; and
- predict fish yield for the same 10 representative species, across space.

Additional detail about the modeling evaluation is provided in Chapter 8.

Sources for Chapter 7

Botsford, L.W., Hastings, A., and Gaines, S.D. 2001. Dependence of sustainability on the configuration of marine reserves and larval dispersal distance. *Ecology Letters* 4: 144-150.

California. Journal of Climate 19: 4308–4325

Carlton, J., G. Chepurin and X. Cao. 2000. A Simple Ocean Data Assimilation Analysis of the Global Upper Ocean 1950–95. Part II: Results. *Journal of Physical Oceanography* 30(2): 311–326.

Carlton, J., G. Chepurin, X. Cao and B. Giese. 2000. A Simple Ocean Data Assimilation Analysis of the Global Upper Ocean 1950–95. Part I: Methodology. *Journal of Physical Oceanography* 30(2): 294–309.

Conil S., and A. Hall. 2006. Local Modes of Atmospheric Variability: A case study of Southern California. *Journal of Climate* 19: 4308–4325

Cowen, R. K., C. B. Paris, A. Srinivasan. 2006 Scaling of connectivity in marine populations. *Science*. 311:522-527.

Dever, E., M. Hendershott, and C. Winant. Statistical aspects of surface drifter observations of circulation in the Santa Barbara Channel. *Journal of Geophysical Research-Oceans*, 103(C11):24781–24797, OCT 15 1998.

Dong, C., and J. McWilliams. 2007. *Vorticity Generation and Evolution in the Shallow-Water Island Wake.*

Dong, C., E. Icida and J. McWilliams. Circulation and Multiple-Scale Variability in the Southern California Bight. *Progress in Oceanography*. In review.

Gaines, S. D., B. Gaylord, and J. Largier. 2003. Avoiding current oversights in marine reserve design. *Ecological Applications*. 13:S32-46

Gaylord, B., S. D. Gaines, D. A. Siegel, M. H. Carr. 2005. Consequences of population structure and life history for fisheries yields using marine reserves. *Ecological Applications*. 15:2180-2191.

Hughes M., A. Hall, R.G. Fovell. 2008. Blocking in areas of complex topography, and its influence on rainfall distribution. *Journal of Atmospheric Science*. Accepted.

Kinlan, B., and S. D. Gaines. 2003. Propagule dispersal in marine and terrestrial environments: a community perspective. *Ecology*. 84:2007-2020.

Kinlan, B., S. D. Gaines, and S. Lester. 2005. Propagule dispersal and the scales of marine community process. *Diversity and Distributions*. 11:139-148.2005.

Shanks, A.L., Grantham, B.A. & Carr, M.H. 2003. Propagule dispersal distance and the size and spacing of marine reserves. *Ecological Applications*, 13, S159–S169.

Siegel, D., B. P. Kinlan, B. Gaylord and S. D. Gaines. 2003. Lagrangian descriptions of marine larval dispersion. *Marine Ecology Progress Series*. 260:83-96.

8. Bioeconomic Modeling

Status of this chapter: The SAT has approved the general approach to the modeling evaluation methods. Refinements to the models and this chapter will continue to be made (Revised by modeling work group March 18, 2009).

For marine protected areas (MPAs) to function effectively as a network that satisfies various goals of the Marine Life Protection Act (MLPA), they must (1) provide adequate protection from harvest to the portion of a species' (adult) population resident in the MPA, and (2) include a sufficient fraction of the populations' total larval production for populations to persist. The science guidelines for MPA design in the *California Marine Life Protection Act Master Plan for Marine Protected Areas* support general evaluation of the efficacy of MPAs as refugia and connectivity within alternative MPA proposals, but do not evaluate potential population effects or account for several variables, including conditions outside the MPA proposal (i.e., harvest), spatial structure of the seascape, realistic connectivity across space, and fishing pressure on different species.

Spatially explicit population models account for these factors and facilitate more comprehensive and spatially explicit evaluation of the consequences of MPA design for a proposal's ability to satisfy various goals of the MLPA. Spatially explicit models developed for evaluation of alternative MPA proposals go beyond the current scope of the master plan guidelines to calculate whether populations will persist and how the proposed MPAs will affect fishery yield and profit. The models include, for example, potential contributions from MPAs that do not satisfy all scientific guidelines, the status of populations outside of MPAs (which depends on fishery management), and the potential costs, in terms of fishery yield, associated with achieving a desired conservation outcome. Further, the models allow us to detect potential situations in which MPAs are sited efficiently, so conservation comes at minimal cost (or perhaps even a benefit) to consumptive users.

This document briefly describes the key inputs and outputs of two models well-suited for analysis of alternative MPA proposals. Also described are the evaluations that will be performed by these models.

Description of Models

In the MLPA North Central Coast Study Region process of the MLPA Initiative, two models were developed, vetted, and utilized to evaluate alternative MPA proposals. Those models are currently being extended for use in the MLPA South Coast Study Region. Both models utilize spatial data on habitat, fishery effort, and proposed MPA locations and regulations to simulate the population dynamics of fished species and generate predicted spatial distributions of species abundances, yields, and (in one case) profits for each alternative MPA proposal. The UC Davis "Spatial Sustainability and Yield" model (UCD model) considers each fished species separately, and focuses on sustainability of fished populations under each MPA proposal, using current estimates of fishery stock status to help predict future management success. The

UC Santa Barbara "Flow, Fish, and Fishing" model (UCSB model) focuses on the tradeoffs between fisheries performance (profits) and fish abundance.[20] Importantly, both models incorporate the population dynamic consequences of spatially explicit fishing regulations.

The two models differ in details regarding, for example, how specifically populations' dynamics are modeled, how the steady-state impacts of fisheries outside of protected areas are parameterized, and what units are used to express conservation and economic values. Although they differ in these details, the two models are structurally similar. Both models have the ability to be run dynamically or to equilibrium, though running dynamically requires data on the starting stock, across space, of multiple species. In equilibrium mode, they predict the state of the system over the long term rather than its dynamics over time[21].

Each model includes more or less the same structural elements: (a) larval connectivity across patches driven by ocean currents, pelagic larval duration, and spawning season, (b) larval settlement regulated by species density in available habitat, (c) growth and survival dynamics of the resident (adult) population, (d) reproductive output increasing with adult size; (e) adult movement (e.g., home ranges), and (f) harvest in areas outside of MPAs.

Key Changes to Models

Both models have been enhanced since they were used in the north central coast. Some of these enhancements are driven by differences in biogeography between the two regions (e.g., more heterogeneous flow patterns in southern California), and some are driven by new methods or data (e.g., the desire to integrate data on fisherman behavior into the models). The key changes in the models are:

- Larval dispersal kernel—they now use output from Regional Ocean Modeling System (ROMS)-based oceanographic models[22] to predict connectivity, rather than assuming homogeneous Gaussian kernels along the coastline.
- Spatial dimension—they represent the coastline as a two-dimensional map (in contrast to the previous one-dimensional representation). This permits more realistic modeling of complex habitat patterns and offshore islands in the Southern California Bight. A one kilometer by one kilometer grid is used for the patches.

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[20] The UCSB model adopts many of the key assumptions of the Equilibrium Delay Difference Optimization Model (EDOM), developed by Walters, Hilborn, and Costello in the MPA North Central Coast Study Region. Both the UCSB and UCD models contain important advances over the versions used in the north central coast to accommodate a more complex biogeography and spatial data on fishing effort in southern California.

[21] Note that equilibrium models do not account for the costs incurred during the time required to reach steady state.

[22] The ROMS model has been developed by oceanographic investigators at UCLA and UCSB who have provided model outputs for use by the spatially explicit population models described in this document. See Chapter 7 – Spacing for additional information on the ROMS model.

- Fleet dynamics—the fleet model is parameterized with data from Ecotrust's surveys of commercial fisheries in southern California, rather than assuming the fleet responds only to changes in fish density. The details of the fleet model are given in Appendix B2.
- Species—with help from the MLPA Master Plan Science Advisory Team (SAT), a list of species has been assembled that covers a wide range of life history and fishery traits that are relevant in southern California (Appendix B3).

1. Variability in larval dispersal—alternative MPA proposals will be evaluated in a variable (rather than static) environment. Larval dispersal matrices will vary among larval years to reflect the interannual variability present in the existing set of ROMS model outputs (years 1996-2002).

Caveats Associated with Model Interpretation

All models necessarily make simplifying assumptions about the nature of real-world processes. Both the UCD and UCSB models rely upon a series of key assumptions about the structural elements (a-f) listed above (Appendix B1). As such, model results should be interpreted with awareness of the assumptions, although these actually are less restrictive than those required by the verbal and mathematical models that form the basis of the size and spacing guidelines in the master plan. For example, the ROMS model used to estimate larval dispersal patterns in the models has limitations in its ability to resolve nearshore circulation, yet is more realistic than the spatially homogenous pattern of connectivity implicitly assumed by the size and spacing guidelines (see Chapter 7 - Spacing for more information on the ROMS model).

Model outputs also depend on the particular parameter values chosen for each species, so the predictions of the models will be most accurate when appropriate parameter values are known. Both modeling teams have undertaken a search of the biological literature for the best estimates of the necessary life history parameters for each model species. In Appendix B3, both modeling teams have detailed the parameter values and literature source for each estimate. This document will be circulated among SAT members and outside experts to ensure that the best parameter estimates have been used, and that these consensus parameter values will be standardized between the two models.

The spatial distributions of larval settlement and adult biomass predicted by the model are driven by two sets of assumptions: 1) larval dispersal is driven by oceanography as predicted by the ROMS model, and 2) the suitability of a particular location for the settlement and growth of a species is determined by the presence of habitat appropriate for that species. Habitat is derived from the regional habitat map developed by DFG and R. Kvitek and is represented in a binary fashion; that is, habitat is either hard- or soft-bottom. Using a rasterized version of these maps, the models consider the fraction of the one square kilometer cell which is suitable habitat (either hard or soft substrate of the appropriate depth, depending on species) to be a continuous measure of habitat availability in the cell. The maximum density of individuals in a cell (carrying capacity) is proportional to this measure of habitat availability.

A limitation to this approach is that it assumes that all locations with the appropriate substrate can support each species, whereas many species in the MLPA South Coast Study Region, including some of those being modeled, have range limits within the study region, and therefore are not found on suitable substrates outside those limits. For example, kelp bass are not found in great numbers, if at all, in the westernmost Channel Islands, despite the abundance of suitable substrate there. The precise mechanisms creating these boundaries are generally unknown and likely reflect a complex combination of factors (e.g., temperature, habitat quality, and the abundance of prey, among others) that are beyond the scope of the current modeling effort. As a consequence, the models sometimes misrepresent abundances outside of these range limits (e.g., the ocean circulation model predicts that kelp bass larvae will settle on San Miguel Island, where no adult kelp bass are actually found). To handle this potential artifact, the models assume that there is no suitable habitat for larval settlement outside of the known range of the species. Larvae arriving in those excluded locations are assumed to die, regardless of the substrate type.

At present, range limits are estimated using existing survey data on species abundances around the study region to estimate range limits primarily the 2004 CRANE survey data. Additional range limit data could be incorporated if provided by the SAT. Note that with this approach, the representation of suitable habitat remains binary: either a location is suitable habitat for a species, or not. Survey data are used to characterize the presence or absence of a species in a location, not actual population densities, which would not be well represented by a single year of survey data. Additionally, the modeling groups are currently exploring the use of satellite-derived sea surface temperature data (from AVHRR satellite images) as an additional measure of habitat suitability in order to represent the north-south trends in abundance of many of the species.

A final caveat is that model results are highly sensitive to the level of fishing outside of MPAs. Because the models are intended to predict a future equilibrium state, it is necessary to predict future fishing levels, an area of high uncertainty. Moreover, the performance of a species under a certain level of fishing is also highly sensitive to the shape of the settler-recruitment relationship (see Table B1 in Appendix B1), which is itself highly uncertain. The precise relationship between fishing effort and the shape of the settler-recruit curve is complex and not perfectly understood, especially in models such as these with considerable spatial complexity. In general, however, it is possible to represent the joint uncertainty in the shape of the settler-recruit curve (biological uncertainty) and in future harvest scenarios (management uncertainty) relative to each other. Specifically, the models describe the shape of the settler-recruit curve in terms of a compensation ratio or critical replacement threshold (CRT), and harvest is described in terms of its effect on the lifetime egg production (LEP) of a species.

For a given value of the CRT, the model results depend roughly on the relative values of CRT and LEP rather than on the particular CRT chosen. In general, the management scenario depends on whether harvest causes lifetime egg production to exceed or fall short of the critical replacement threshold set by the settler-recruit relationship. Expressing the effects of harvest in terms of lifetime egg production also reduces some of the dependence of model results on uncertainty about adult life-history parameters. Therefore, it is possible to represent both biological and management uncertainty by choosing a particular value for the CRT for each species and then simulating population dynamics under several different harvest regimes relative to that CRT. The models will simulate harvest regimes that will approximate poorly managed, MSY-like management, and conservatively managed scenarios, given that CRT.

Thus the model results can illustrate a range of possible performance for each species. For concise interpretation (i.e., coming up with several summary results for each alternative MPA proposal) it may be desirable to weight results across species or possibly weight the probability of different future management outcomes.

SAT Recommendations for Using Models to Compare Alternative MPA Proposals

Because the models are built on the best available science, the SAT recommends that these models be among the principal modes of evaluation for each alternative MPA proposal in the MLPA South Coast Study Region. In making this recommendation, the SAT emphasizes that the models' conceptual principles are consistent with those upon which existing MPA size and spacing guidelines are based, and yield similar general conclusions: MPA size relative to adult movement strongly determines MPA effectiveness, and MPA spacing relative to larval dispersal distance strongly determines the ability of MPAs to function as a network. Spatially explicit modeling is more comprehensive in that it integrates the effects of MPA size and spacing, habitat distribution, level of fishing, and adult and larval movement to quantify the effectiveness of an alternative MPA proposal. In doing so, the models extend the scope of the evaluation of alternative MPA proposals currently addressed by the size and spacing guidelines. Moreover, spatially explicit models are not susceptible to threshold-related sensitivity that can arise from evaluation based on the size and spacing guidelines (i.e., that specific sizes and spacing (or ranges of these) are adequate, but others are not). Rather they estimate the conservation and economic consequences of each proposed spatial configuration of MPAs, so that they can be evaluated directly.

The UCD and UCSB models produce similar outputs that can be used to evaluate these conservation and economic consequences. Both models produce a measure of *conservation value* (e.g. increases in biomass or population sustainability), and a measure of *economic return* (e.g. yield or fishery profitability). Both conservation value and economic return can be described study-region wide or can be made spatially explicit. The models calculate each output at three spatial scales: individual one kilometer by one kilometer cells, the entire study region, and four sub-areas (the mainland south of Long Beach Harbor, the mainland north of Long Beach Harbor, the northern islands [San Miguel, Santa Rosa, Santa Cruz, Anacapa, Santa Barbara] and the southern islands [San Nicolas, San Clemente, Santa Catalina]). Conservation value is essentially a measure of the effectiveness of an alternative MPA proposal at meeting MLPA goals 1, 2, and 6[23], while economic return reflects the expected changes to fishing yields of implementing MPAs. Specifically, each model will output:

1. Conservation Value
   a. [UCD] Biomass and larval supply (a proxy measure of population sustainability) of 10 or so representative species, across space, under each alternative MPA proposal (including "No Action").
   b. [UCSB] Biomass of 10 or so representative species, across space, under each alternative MPA proposal (including "No Action").

[23] Subsections 2853(b)(1), (b)(2), and (b)(6), Fish and Game Code.

   c. If A=Conservation Value under Proposal X, and B=Biomass under No Action, then the quotient: (A-B)/B provides a measure of the percentage increase in conservation value compared with No Action.
2. Economic Return
   a. [UCD] Fish yield of 10 or so representative species, across space, for each alternative MPA proposal
   b. [UCSB] Fish yield and Fisheries Profit for the 10 or so representative species, across space, for each alternative MPA proposal
   c. Again, by comparing to "No Action", one can generate a measure of the percentage increase or decrease in economic return from the proposal.

The SAT proposes that each alternative MPA proposal be evaluated by compiling the following outputs:

1. Spatial effects on Conservation Value (as percentage changes versus No Action, presented as a spatial map and averages for each sub-area)
   a. For each model species
   b. For a weighted average of all model species (SAT to determine weights)
2. Region-Wide effects on Conservation Value
   a. For each model species
   b. For a weighted average of all model species (SAT to determine weights)
3. Spatial effects on Economic Return (presented as a spatial map and averages for each sub-area)
   a. For each model species
   b. For a weighted average of all model species (SAT to determine weights)
4. Region-Wide effects on Economic Return
   a. For each model species
   b. For a weighted average of all model species (SAT to determine weights)
5. Spatial effects on Recruitment (presented as a spatial map and averages for each bioregion)
   a. For each model species
   b. For a weighted average of all model species (SAT to determine weights)
6. Spatial fishing intensity
   a. For each model species
   b. For a weighted average of all model species (SAT to determine weights)
7. Connectivity diagrams: the larval dispersal kernel that shows the intensity of connections from all source to all destination locations.
8. Tradeoff Curves: plot Conservation Value against Economic Return for each MPA proposal

All analyses will take place over a range of assumptions, e.g. with respect to fishing intensity, adult home range size, etc. (See Appendix B1).

Using Model Outputs to Improve Each MPA Network Proposal

In addition to the outputs being used to compare alternative MPA proposals, both models also produce outputs which can be used to evaluate the strengths and weaknesses of each design. These outputs are intended provide feedback during the iterative design process so that proposals can be adjusted to improve their performance in terms of conservation value and (if desired) economic value.

Three kinds of feedback are provided for each species:

- The models calculate changes in conservation and economic value on sub-area scales. These data can be used to evaluate how the effects of alternative MPA proposals varies over space, and if necessary to revise the proposals to correct spatial imbalances in effects. The sub-areas used are the southern mainland (Long Beach harbor south to the Mexican border), northern mainland (Long Beach harbor north to Pt. Conception) northern islands (San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara) and southern islands (San Nicolas, Santa Catalina and San Clemente). In each sub-area, conservation value is calculated by comparing biomass in the sub-area with the MPA proposal to biomass in the sub-area without fishing. In each sub-area, economic value is calculated by comparing profit (or yield) in the sub-area with the MPA proposal to profit (or yield) in the sub-area with no new reserves. Examples of these outputs as produced by the UCSB model are given in Figures B4.1 and B4.2 of Appendix B4.
- The models calculate how much biomass is in each MPA, what fraction of the larvae arriving in that MPA were produced within the MPA (self-recruitment), and to what degree the MPA is self-sustaining (self-persistence). The first metric will allow a determination of which MPAs are in locations that support large populations of the target species and which are poorly placed to protect that species. The second metric (self-recruitment) allows a determination of to what extent each MPA is seeded with larvae originating elsewhere, as opposed to being replenished primarily by larvae spawned within that MPA. The third metric (self-persistence) is related and determines whether the MPA would persist in isolation; this is subtly different from self-recruitment, in that an MPA may receive a huge influx of larvae from other sources (low fraction of self-recruitment) but might nonetheless persist on its own. Conversely, an MPA may be highly self-recruiting, but if the total number of self-produced larvae is very low, the population in the MPA may not be persistent. Examples of these outputs as produced by the UCSB model are given in Figures B4.3 and B4.4 of Appendix B4.

1. The models also calculate how conservation value and economic value would vary for an alternative MPA proposal if one of the proposed MPAs was not implemented. That is, the model is run for a particular alternative MPA proposal, which contains *m* individual MPAs. Then *m* additional model runs are made. In each run, one of the MPAs is ‘deleted’ from the proposal. The outcome of these deletion runs is then compared to the run with the full proposal. By comparing the performance of the proposal with and without each individual MPA, the relative importance of each MPA can then be determined. If the proposal with a particular MPA removed performs similarly to the whole, intact proposal, then the given MPA is not contributing greatly to various MLPA goals, and could be altered to improve its effectiveness at meeting those goals.

Alternatively, if removing an MPA causes a sharp decrease in overall performance, then that MPA is performing well at meeting those goals and should probably not be reduced in size or repositioned. Examples of these outputs as produced by the UCSB model are given in Figures B4.5 and B4.6 of Appendix B4.

In interpreting these feedback outputs, it is important to recognize that the performance of an alternative MPA proposal or a particular MPA within that proposal is determined by the interplay of multiple factors, often in nonlinear ways. Therefore “improving” the performance of a particular MPA could be accomplished by varying any one of a number of factors (including size, shape, coverage of habitat in the vicinity, distance to neighboring MPAs, position relative to oceanographic retention zones, etc.). However, lessons drawn from simpler models of population dynamics within MPAs (e.g,, Crowder et al. 2000, Botsford et al. 2001, Gaines et al. 2003, Moffitt et al. *in press* – need to add citations) do suggest the consequences of adjusting different MPA features. In general, MPAs will afford better protection to a species if it is made larger relative to the home range radius of that species. An MPA is more likely to be self-sustaining and independently persistent if it is larger (so that a greater fraction of larvae produced within that MPA return to replenish the population within the MPA) and if it is positioned in a location with higher oceanographic retention (larger values on the diagonal of the larval connectivity matrix). MPAs may also support large populations if they are situated such that they receive large inputs of larvae from ‘upstream’ locations, although then the performance of the ‘downsteam’ MPA is tied to the persistence of the population in the ‘upstream’ location. Similarly, it may be advantageous to locate MPAs such that they export many larvae to ‘downstream’ locations (determined by looking at the off-diagonal elements of the connectivity matrix in the horizontal rows corresponding to that MPA as a larval origin). However, the successful export of larvae will still depend on whether the ‘source’ MPA maintains a large, persistent population.

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Figure 8-1. Example of Spatial Map of Conservation Value Generated by UCD Model

The map shows the equilibrium biomass for one species (kelp bass) in each model cell.

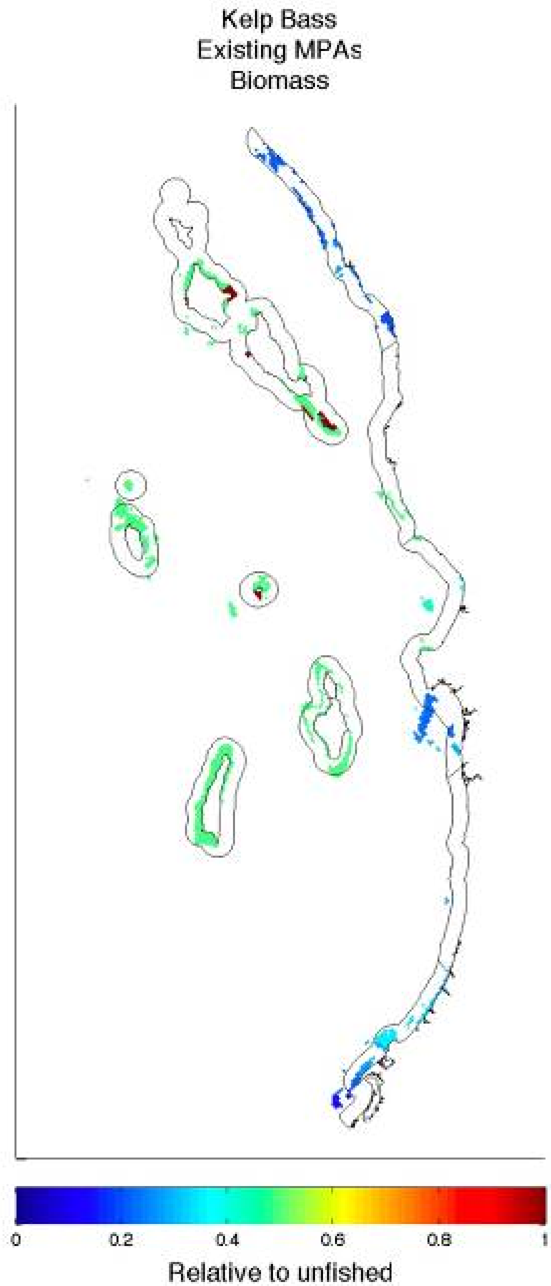


Figure 8-2. Example of Spatial Map of Economic Return Generated by UCD Model

The map shows the equilibrium yield for one species (kelp bass) in each model cell. [This map is a draft and may be altered for the final document.]

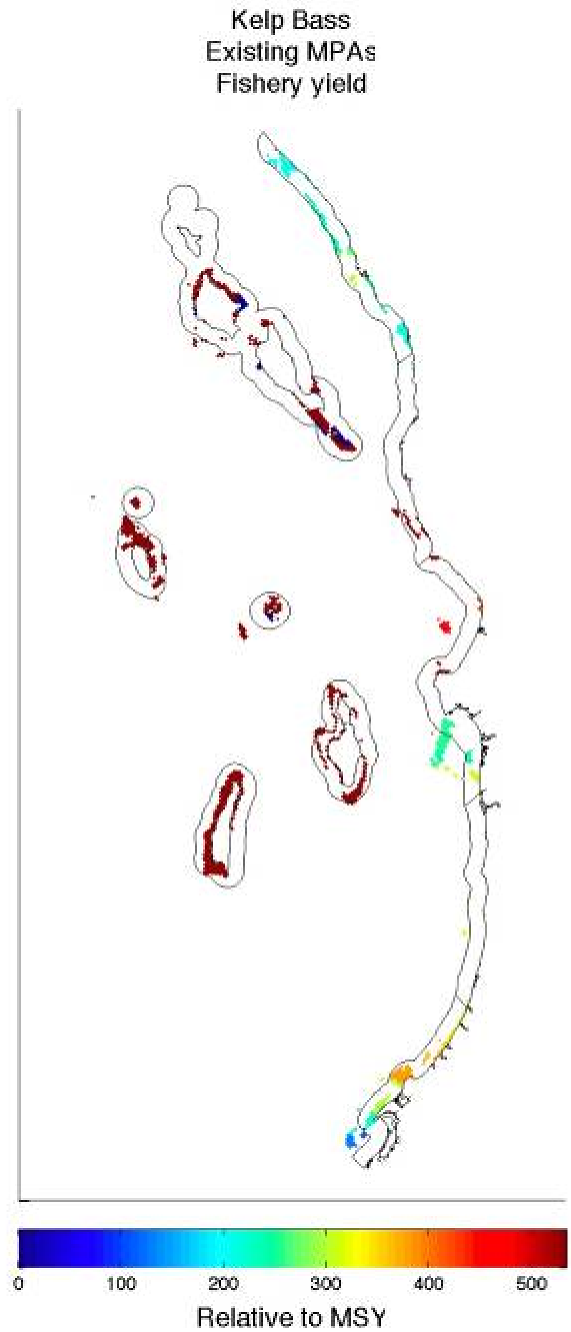


Figure 8-3. Example of Spatial Map of Recruitment Generated by UCD Model

The map shows the equilibrium larval recruitment for one species (kelp bass) in each model cell.

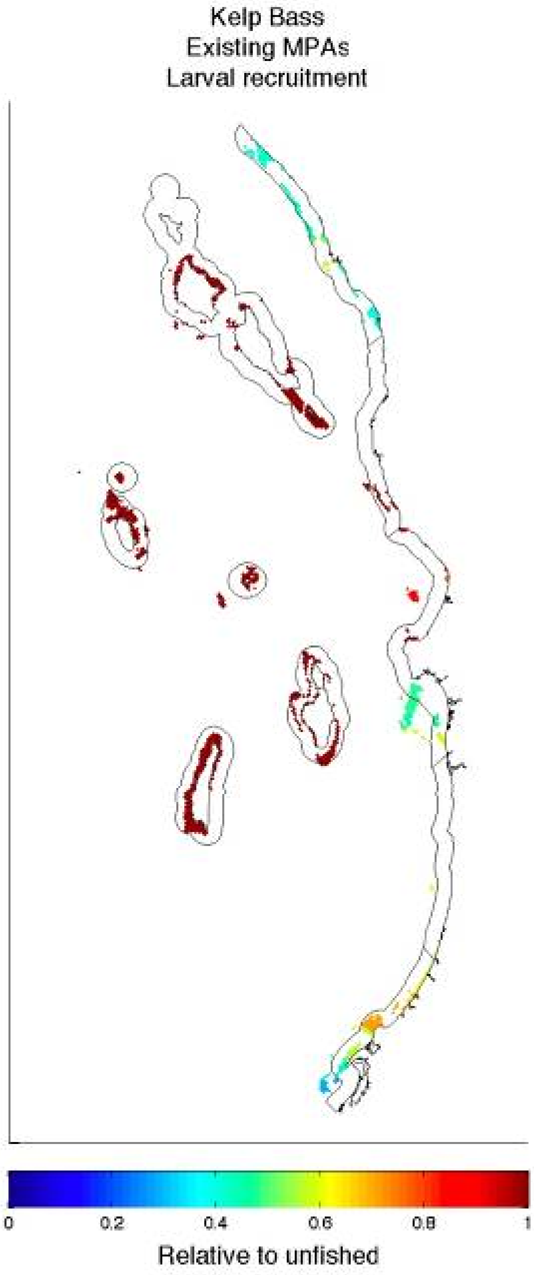


Figure 8-4. Example of Spatial Map of Fishing Generated by UCD Model

The map shows the equilibrium fishing rate for one species (kelp bass) in each model cell.

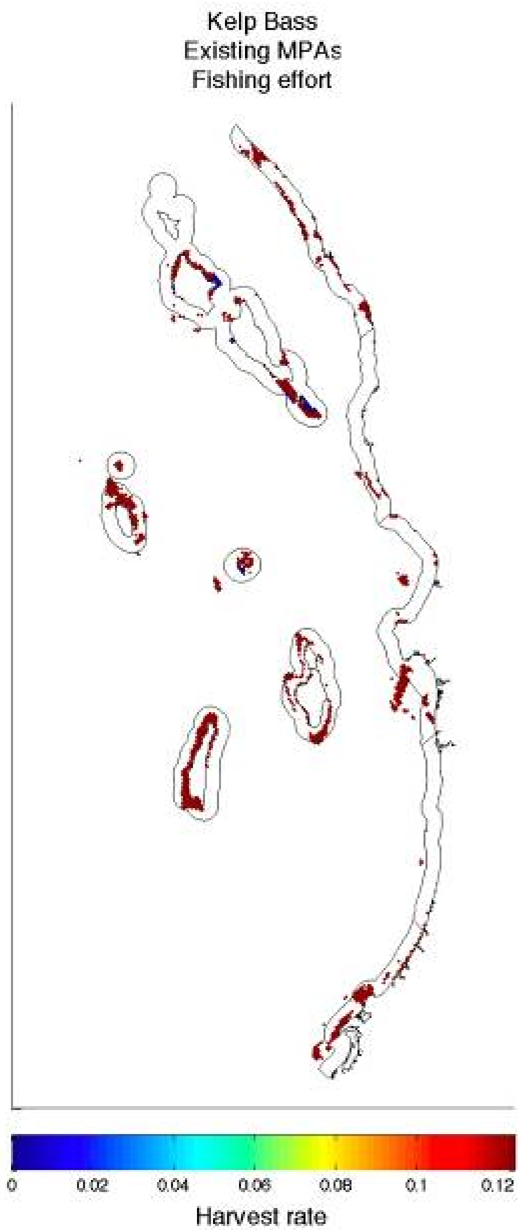


Figure 8-5. Example of Connectivity Matrix Used by Models

Color intensity at each point shows the probability of dispersal of kelp bass larvae from an origin patch (along vertical axis) to a destination patch (along horizontal axis). Points are grouped by geographical region (see Chapter 8 for description). [This is a draft; a revised version with more geographical landmarks denoted is forthcoming.]

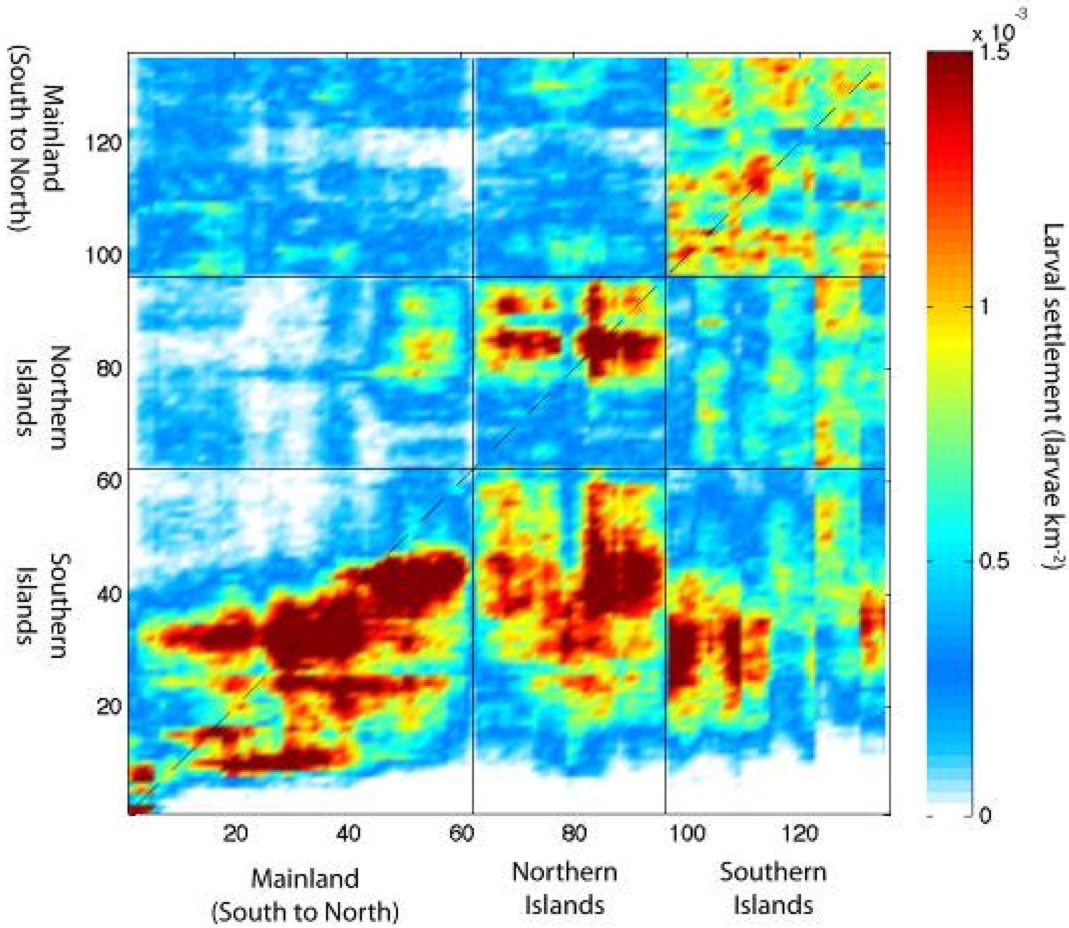
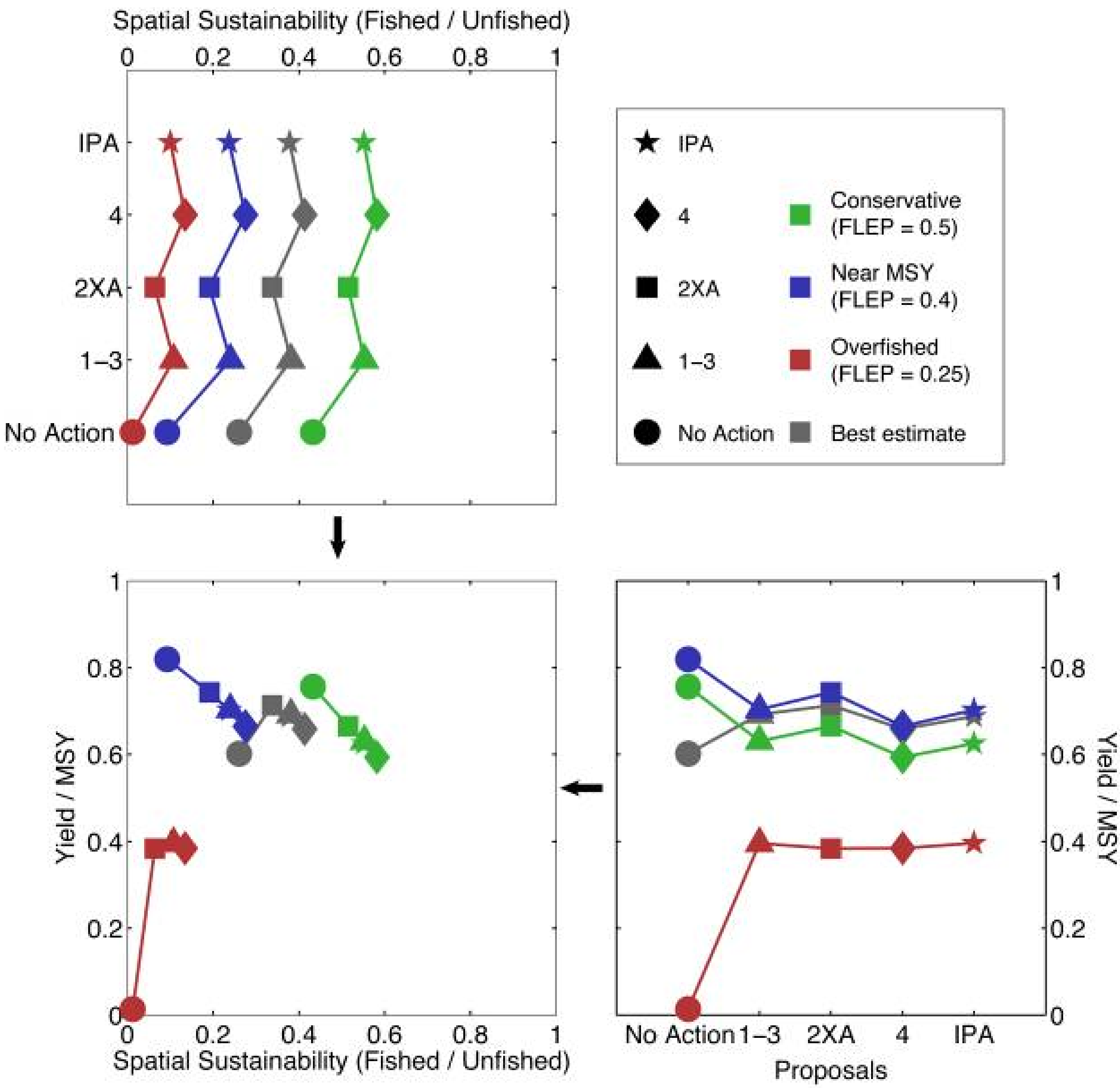


Figure 8-6. Example of Tradeoff Curve Produced by Models

This example shows a comparison of four MPA proposals and the No Action alternative from the MLPA North Central Coast Study Region. [An example using data from the MLPA South Coast Study Region is forthcoming.] The top left panel shows the Conservation Value metric ('spatial sustainability,' a measure of population persistence estimated by the NCCSR UCD model) for each proposal; the bottom right panel shows the Economic Value metric (yield as a proportion of maximum sustainable yield) for each proposal, and the bottom left panel shows the tradeoff curve for both metrics for each proposal. Model results were generated using three different assumptions about the future success of fishery management outside of MPAs and one scenario in which past management success was used to predict future success ("best estimate"), these different scenarios are indicated by different colors in the figure.



9. Protection of Marine Birds and Mammals

Status of this chapter: The SAT has approved of the evaluation methods in this chapter.

Marine protected areas (MPAs) may benefit marine birds and mammals by protecting their forage base and by potentially reducing human disturbance to roosting and haul-out sites, and breeding colonies or rookeries. To evaluate the protection afforded by proposed MPAs to birds and mammals the SAT does the following:

- identifies proposed MPAs or special closures[24] that contribute to protection of birds and mammals
- identifies focal species likely to benefit from MPAs and for which data are available
- estimates the proportion (of total numbers of individuals) of breeding bird/mammal at colonies and rookeries potentially benefiting by proposed MPAs
- estimates the proportion of nearby foraging areas protected by MPAs, defined by evaluating protection of buffered areas around colonies
- estimates the number of neritic foraging 'hot spots' protected by MPAs, defined by at-sea densities of marine birds and mammals
- estimates the proportion of estuarine and coastal beach inhabitants protected by MPAs

This evaluation focuses on pinnipeds (seals and sea lions), nearshore delphinids (e.g. coastal bottlenose dolphin), and birds, including seabirds, shorebirds, and waterfowl[25]. Population, as used in this evaluation, refers to the number of animals that use a site for breeding or resting. Evaluations are focused on the five bioregions identified by the SAT. Evaluations include numbers of species (species diversity), numbers of individual birds or mammals, and percentages of bioregional populations breeding within individual proposed MPAs and within all proposed MPAs. Species evaluated are limited to those identified as likely to benefit from MPAs and special closures with an emphasis on species identified as most likely to benefit.

The SAT evaluation for marine birds and mammals focuses on:

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[24] Special closures are not MPAs, but could restrict access to discrete areas to prevent human disturbance to colonies, rookeries, haul-outs, and roosts. Special closures may be included in future rounds of the marine birds and mammals evaluations if included in MPA proposals; they would be evaluated with regard to marine birds and mammals using similar methods as used for MPAs.

[25] Cetaceans are included only in foraging analyses (i.e., 3 and 4), because there is limited data about fine-scale use patterns for these species and it is unknown whether they would directly or measurably benefit from the size of MPAs being defined, given their relatively large-scale movements.

1. Protection of seabird breeding colonies and pinniped rookeries based on population size, location and species composition

This analysis examines whether MPAs and special closures proposals will benefit the species identified as likely to benefit. Evaluations are based on the numbers of animals in the MLPA South Coast Study Region, and the proportion within each bioregion, and within the proposed MPA or special closure area. For each colony within a proposed protection area, the SAT considers the likely effect of the specific protections or regulations identified (e.g. no-entry zones) that would reduce human disturbance, and whether the MPA or special closure area affects significant numbers of animals. Special closure areas will provide maximum benefit by minimizing disturbance caused by boats, irrespective of vessel type. MPAs that restrict fishing or other activities in waters surrounding colonies would provide less benefit than no-entry zones but likely would provide a benefit by reducing the numbers of boats approaching and lingering near colonies. Possible benefits of reduced disturbance include increased bird/mammal productivity, colony/population size, and species diversity (Carney & Sydeman 1999) (Rojek et al 2007).

Data used for these assessments comes from the National Oceanic and Atmospheric Administration (NOAA)/U.S. Fish and Wildlife Service (USF&WS) bird colony database[26], from pinniped data compiled from Mark Lowry and Sharon Melin (NOAA Fisheries), and other sources. The SAT evaluates total numbers of seabirds and pinnipeds, and the proportion breeding by species for each bioregion, and for all species combined, within each proposed MPA or special closure. The sizes of special closures vary, but usually range between 300 and 1000 feet.

2. Marine bird and pinniped resting (roost/haulout/raft) locations based on population size, location and species composition

Many marine birds and pinnipeds require areas close to foraging locations where they can safely come to shore to rest, sleep, dry (i.e., cormorants, pelicans), or molt (some pinnipeds). Frequent disturbance at resting sites results in high levels of energy expenditure that can lead to poor body condition and/or cause animals to abandon the area (Carney & Sydeman 1999) (Rojek et al 2007).

The methods the SAT uses to assess roosting areas and haulout sites are similar to those used for colonies/rookeries. For seabirds, the SAT uses data on major Brown Pelican roosts, which also serve as a surrogate for other species. For pelicans, major roosts have been categorized as those typically containing: 1) 100-500 birds; 2) 500-1,000 birds; and 3) > 1,000 birds. For pinnipeds, total numbers and the proportion in each bioregion are calculated for each species and for all species combined, and haulout sites are evaluated based on these proportions.

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[26] Original data is from Carter 1980 and Sowles 2000. These data were then updated in 2004 with information mostly in Baja California from Wolfe SG 2002 using the same format.

3. Marine bird and pinniped near-colony/rookery foraging concentrations based on population size, location, and species composition

As upper-trophic-level predators, seabirds and marine mammals require an abundance of resources for survival and reproduction. With long life expectancies (>20 years), low annual productivity, and high site fidelity, these animals are subject to population level impacts from reduced prey supplies or disturbance at foraging areas. High levels of disturbance at foraging areas can cause increased energy expenditure leading to poor body condition; this can be especially detrimental for species with long migration routes, which may not have sufficient energy reserves to complete migration. Thus, protection of important prey species and foraging areas could have benefits, especially to species with limited foraging distributions.

For breeding species, the SAT will focus on five seabird and one marine mammal species most likely to benefit based on limited foraging ranges. For birds, this analysis focuses on the Pelagic Cormorant, Brandt's Cormorant, Pigeon Guillemot, California Least Tern, and Bald Eagle. For pinnipeds, this analysis focuses on the harbor seal. These species mainly forage in nearshore waters within a few miles of colonies. However, other species are likely to benefit (e.g. Double-crested Cormorant, Forster's Tern, Caspian Tern, Black Skimmer, Guadalupe fur seal, northern fur seal, long-beaked common dolphin and coastal bottlenose dolphin).

Evaluations of benefits to marine birds and mammals near colonies are based on whether or not proposed regulations may benefit forage species (Table 9-1) or foraging habitats, how much foraging area will be protected near breeding areas, and how many animals stand to benefit. Zones extending three miles alongshore and to three miles offshore (the main foraging range of these species when breeding) from breeding colonies/rookeries are used to examine the numbers of birds/mammals utilizing the area within the proposed MPA.

4. Marine bird and mammal neritic foraging based on location, bird density, and species composition

There are many hydrographic features within the neritic zone of state waters that will concentrate the prey of many marine birds and mammals. Retention areas and thermal fronts adjacent to upwelling centers and river plumes are known to concentrate prey. These areas are often referred to as 'hot spots', or areas of high trophic transfer, as they provide essential foraging opportunities to upper trophic level predators. While the types of prey typically found at hot spots are highly mobile (e.g. anchovies, squid, and krill), they will benefit from MPAs protecting hot spots as they have a high probability of being concentrated in these areas. Any protection given to hot spots will ultimately translate into added marine bird and mammal protection. At-sea densities for the following 11 species will be plotted over proposed MPAs to determine the number of species and densities likely to benefit: Western Grebe, Sooty Shearwater, Brown Pelican, Brandt's Cormorant, Red Phalarope, Heermann's Gull, California Gull, Western Gull, Black-legged Kittiwake, Caspian Tern, and Cassin's Auklet. At-sea distributions from Mason et al. (2007) will be used for these analyses. Additionally, at-sea densities or encounter rates of coastal bottlenose dolphin will be plotted over proposed MPAs to evaluate potential benefits. Data available from the Channel Islands National Marine Sanctuary (CINMS) will be used for evaluation.

5. Estuarine and coastal beach protection for resident and migrant shorebirds and waterfowl

The SAT evaluates whether proposed MPAs provide protection to the inhabitants of estuarine areas. There are many human activities, including hunting, that take place within estuaries and have adverse effects on shorebird and waterfowl populations. Estuaries provide critical resting and foraging habitat for resident and migrant birds. However, with the loss of estuarine habitat in southern California over recent decades, coastal beach habitat has become increasingly important to displaced populations (J. Dugan pers. comm.). Protecting both estuarine and coastal beach habitat, even if limited to below mean high tide, will have direct benefit to these populations. The best available data for this analysis come from Audubon Christmas Bird Counts. Christmas Bird Counts are collected through a standardized citizen-science-based program coordinated by the National Audubon Society. Data are collected annually by volunteer groups throughout the nation. Each group defines an approximately 25 km radius circle and collects data within this circle during a selected 24 hour period, with all groups nationwide completing data collection within a few weeks of 25 December. For the SAT analysis, data from Audubon Christmas Bird Counts will be plotted over proposed MPAs to determine the abundance and number of species likely to benefit.

Table 9-1. Known Important Prey Items of Bald Eagle, Brandt's Cormorant, California Least Tern, Pelagic Cormorant, Pigeon Guillemot, Harbor Seal, California Sea Lion, and Coastal Bottlenose Dolphin in Southern California.

Note: Most fish taken by seabirds are in the juvenile stage.

Species	Prey	Preferred Foraging Habitat
Bald Eagle	**Fish** Rockfish *Sebastes* spp. Surfperch (Embiotocidae) Pile Perch *Damalichthys vacca* Cabezon *Scorpaenichthys marmoratus* Midshipman *Porichthys* spp. California sheephead *Semicossyphus pulcher* Pricklebacks (Stichaeidae) Bocaccio *Sebastes paucispinis* Halfmoon *Medialuna californiensis* White seabass *Atractoscion nobilis* Topsmelt *Atherinops affinis* **Invertebrates** California mussel *Mytilus californianus* Other bivalves, limpets Sea urchin *Strongylocentrotus* spp. **Marine birds** Eared Grebe *Podiceps nigicollis*	

Species	Prey	Preferred Foraging Habitat
	Sooty Shearwater *Puffinus griseus* Cormorants *Phalacrocorax* spp. California Gull *Larus californicus* Common Murre *Uria aalge* Rhinoceros Auklet *Cerorhinca monocerata* Cassin's Auklet *Ptychoramphus aleuticus* Waterfowl (ducks, scoters, mergansers)	
Brandt's Cormorant	**Fish** Short-belly rockfish *Sebastes jordani* Yellowtail rockfish *Sebastes flavidus* Other rockfish *Sebastes* spp. Pacific sandlance *Ammodytes hexapterus* Plainfin midshipman *Porichthys notatus* Speckled sanddab *Citharichthys stigmaeus* White seaperch *Phanerodon furcatus* Northern anchovy *Engraulis mordax* Pacific herring *Clupea pallasi* Pacific staghorn sculpin *Leptocottus armatus* *Hemilepidotus* spp. (Cottidae) Other sculpins (Cottidae) Pacific tomcod *Microgadus proximus* Northern Pacific hake *Merluccius productus* Shiner perch *Cymatogaster aggregata* Pacific tomcod *Microgadus proximus* Spotted cusk-eel *Chilara taylori* Butter sole Isopsetta isolepis Rex sole *Glyptocephalus zachirus* English sole *Parophrys vetulus* **Invertebrates** Market squid *Loligo opalescens*	Soft bottom
California Least Tern	**Fish** California killifish (*Fundulus parvipinnis*) Sculpins (Cottidae) Surfperch (Embiotocidae) Silverside smelt (Atherinidae) Anchovy (*Anchoa sp.*) Northern Anchovy (*Engraulis mordax*) Pacific Saury (*Cololabis saira*) – not in good years	Estuarine/lagoons and nearshore coastal

Species	Prey	Preferred Foraging Habitat
	Cabezon (*Scorpaenichthys marmoratus*) Rockfish (*Sebastes sp.*)	
Pelagic Cormorant	**Fish** Short-belly rockfish *Sebastes jordani* Yellowtail rockfish *Sebastes flavidus* Other rockfish *Sebastes* spp. Sculpins (Cottidae) *Coryphopterus nicholsii* *Chilara taylori* **Invertebrates** Shrimp *Spirontocaris* sp.	Submerged reefs
Pigeon Guillemot	**Fish** Rockfish *Sebastes* spp. Pacific sanddab *Citharichthys sordidus* Blennies (Clinidae) Sculpins (Cottidae) Gunnels (Pholidae) Spotted cusk-eel *Chilara taylori* **Invertebrates** Red octopus *Octopus rufescens*	Submerged reefs
Harbor seal	**Fish** Rockfish *Sebastes* spp. Pacific sandlance *Ammodytes hexapterus* Plainfin midshipman *Porichthys notatus* Speckled sanddab *Citharichthys stigmaeus* Northern anchovy *Engraulis mordax* Pacific herring *Clupea pallasi* Pacific staghorn sculpin *Leptocottus armatus* *Hemilepidotus* spp. (Cottidae) Other sculpins (Cottidae) Pacific tomcod *Microgadus proximus* Northern Pacific hake *Merluccius productus* Shiner perch *Cymatogaster aggregata* Spotted cusk-eel *Chilara taylori* Butter sole *Isopsetta isolepis* Rex sole *Glyptocephalus zachirus* English sole *Parophrys vetulus* Salmonid	

Species	Prey	Preferred Foraging Habitat
	Lamprey Hagfish Walleye pollock Starry flounder, *Platichthys stellatus* Pile perch, *Rhacochilus (Damalilicthys) vacca* **Invertebrates** shrimp *Spirontocaris* spp. Market squid *Loligo opalescens* Octopoda spp. Crustacea Bivalve mollusk	
California sea lion	**Fish** Northern anchovy Pacific whiting Jack mackerel Rockfish spp. Pacific (chub) mackerel Blacksmith Senorita Plainfin midshipman **Invertebrates** Market squid Octopus spp. Squid spp. Pelagic red crab	
Coastal bottlenose dolphin	**Fish** Croaker spp., Family Sciaenidae Barracuda, *Sphyraena argentea* Jack mackerel, *Trachurus symmetricus* **Invertebrates** Market squid, *Loligo opalescens*	

Sources for Table 9-1: Data on seabird prey items from Ainley, D.G., C.S. Strong, T.M. Penniman, and R.J. Boekelheide. 1990. The feeding ecology of Farallon seabirds. Pp. 51-127 in (D.G. Ainley and R.J. Boekelheide, eds.), *Seabirds of the Farallon Islands: Ecology, Dynamics, and Structure of an Upwelling-system Community*. Stanford University Press, Stanford, California. Data on Bald Eagle prey items, limited to marine prey items only, from Erlandson, J.M., T.C. Rick, P.W. Collins, and D.A. Guthrie. 2007. Archaeological implications of a bald eagle nesting site at Ferrelo Point, San Miguel Island, California. *Journal of Archaeological Science* 34: 255-271; and Sharpe, P.B. 2002. Restoration and Management of Bald Eagles on Santa Catalina Island, California, 2002. Report prepared for the U.S. Fish and Wildlife Service, Sacramento, Ca. November, 2002. Data on California Least Tern prey items from Robinette, D. 2003. *Partitioning of food resources by four sympatric terns (Aves:*

Laridae) breeding in southern California. Master's Thesis. California State University, Long Beach; Robinette, D. and J. Howar. 2008. Monitoring and management of the California Least Tern colony at Purisima Point, Vandenberg Air Force Base, 2007. Unpublished Report, PRBO Conservation Science, Petaluma, CA. Data on harbor seal prey items from Harvey JT, Helm R, Morejohn G. (1995) Food habits of harbor seals inhabiting Elkhorn Slough, California. *Calif. Fish and Game*. 81:1-9; Antonelis, G.A. and C.H. Fiscus. 1980. The Pinnipeds of the California Current. *CalCOFI Rep*., Vol. XXI. Data on California sea lion prey items from Lowry MS, BS Stewart, CB Heath, PK Yochem, and JM Francis. 1991. Seasonal and annual variability in the diet of California sea lions Zalophus californianus at San Nicolas Island, California, 1981-1986. *Fishery Bulletin*, U.S. 89:331-336. Data on coastal bottlenose dolphin prey items from Schwartz, M. L., A. A. Hohn, H. J. Bernard, S.J. Chivers, and K. M. Peltier. 1992. Stomach contents of beach-cast cetaceans collected along the San Diego County coast of California, 1972-1991. *NMFS-SWFSC- Administrative Report* LJ-92-18. 33pp.

Sources for Chapter 9

Carney, K.M. and W.J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. *Waterbirds* 22:68-79.

Rojek, N.A., M.W. Parker, H.R. Carter, and G.J. McChesney. 2007. Aircraft and vessel disturbances to Common Murres *Uria aalge* at breeding colonies in central California, 1997–1999. *Marine Ornithology* 35: 67–75.

10. Water and Sediment Quality

Status of this chapter: The SAT is currently in the process of developing an evaluation for water and sediment quality. This chapter will be updated once this evaluation is developed.

While water quality is not subject to management under the MLPA, it may be important in designing MPA proposals. Where water quality is significantly compromised, marine life may be affected. Impaired water quality may lead to changes to population rates (growth, reproduction, and mortality), population abundance, and ecological community composition through a variety of interactions (e.g. decreased diversity, loss of sensitive species, and abundance of tolerant species).

For MPA network design, the SAT recommends including areas already designated as areas of special biological significance (ASBSs) because these areas benefit from protection beyond that offered by standard waste discharge restrictions. The SAT recommends avoiding locations of poor or threatened water quality, including

- major cooling water intake sites for power plants,
- municipal sewage or industrial outfalls, and
- areas that are significantly impacted by a variety of pollutants from large industrial or developed watersheds.

The SAT determined that MPAs may be placed in or near areas of impaired water quality (e.g. Santa Monica Bay) if there are other reasons to place MPAs in such areas.

Since water quality evaluations are not mandated by the MLPA, these guidelines based on consideration of water quality are secondary to other MPA network design guidelines. Other guidelines (including bioregions, habitat representation and replication, and MPA size and spacing) should be used to drive design of alternative MPA proposals. Water quality considerations may be incorporated if other guidelines have been met. The SAT has not yet completed a methodology for evaluating alternative MPA proposals. Details about the evaluation of MPA proposals for water quality will be updated pending SAT discussions and recommendations.

11. Recreational, Educational, and Study Opportunities (Goal 3)

STATUS OF THIS CHAPTER: This is a staff analysis

The MLPA's Guidelines and Evaluation Methods Related to Goal 3 Analyses

Goal 3 of the Marine Life Protection Act (MLPA) is:

> "To improve *recreational, educational*, and *study opportunities* provided by marine ecosystems that are subject to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity."

MLPA Initiative and the California Department of Fish and Game (DFG) staff will evaluation existing MPAs (Proposal 0), as well as South Coast Regional Stakeholder Group (SCRSG) marine protected area (MPA) proposals for their fulfillment of MLPA's Goal 3.

Access is a key issue for recreational, education and study opportunities; the evaluation focuses on proximity of MPAs to access points, boat and kayak launches sites, state parks adjacent to the ocean, and marine research institutions. The number of long-term monitoring sites inside MPAs and the replication of habitats within MPAs are also tabulated.

The following is a summary of the seven parameters that will be used to evaluate MPA proposals relative to Goal 3:

1. coastal access points within and near proposed MPAs
2. boat and kayak launch sites within or near proposed MPAs
3. ports and harbors within given distances of proposed MPAs
4. California State Parks located adjacent to MPA boundaries
5. major marine research and educational institutions within given distances of proposed MPAs
6. long-term marine research monitoring sites located within proposed MPAs
7. replication of habitats within the study region

Two additional evaluations that take Goal 3 of the MLPA into consideration are

- the California Department of Fish and Game's feasibility analysis, and
- the Ecotrust evaluation of potential impacts to areas of importance to recreational fishing modes

Methodology

MLPA Initiative and DFG staff will use simple metrics and the best readily available geographic information system (GIS) data to evaluate the extent to which MPA proposals address Goal 3 of the MLPA. This evaluation will compare MPA proposals to one another and to the existing MPAs (Proposal 0).

Evaluation of recreational opportunities focuses on accessibility of different types of MPAs, specifically:

- *Coastal access points within and near proposed MPAs*. In total, there are 404 access points that are mapped in the south coast study region. Existing data on access points come from the California Coastal Access Guide. For this parameter, it is evaluated to determine the number of access points located inside MPA boundaries or within two miles for proposed MPAs with: a) very high level of protection (LOP), b) high and moderate-high LOP, and c) all levels of protection. Only shoreline MPAs will be considered in the evaluation of access. Access points that are within the border of an MPA and within two miles of another MPA are only counted once.
- *Boat and kayak launch sites within or near proposed MPAs*. There are 116 sites that are mapped in the study region and they include: boat ramps, kayak launch sites, and boat launch sites. Launch sites will be counted if located inside MPA boundaries, within two miles, or within two to five miles of proposed MPAs. This parameter is also evaluated for proposed MPAs with: a) very high level of protection (LOP), b) high and moderate-high LOP, and c) all levels of protection. The distance of five miles reflects potential use of MPAs by users with small water craft.
- *Ports and harbors within given distances of proposed MPAs.* Eighteen ports and harbors exist in the study region. Each proposed MPA will be evaluated to determine the number of ports and harbors: within 0-5 miles, 5-15 miles, or 15-50 miles. Proposed MPAs are separated out by those with: a) very high level of protection (LOP), b) high and moderate-high LOP, and c) all levels of protection.
- *California State Parks located adjacent to MPA boundaries*. There are thirty-two state parks located on the coast adjacent to the Pacific Ocean in the south coast study region. The information is provided by California State Parks with individual park information from the various districts in the region. State parks will be counted if they intersect (are adjacent to) onshore MPAs and their associated boundaries. This parameter is also evaluated for proposed MPAs with: a) very high level of protection (LOP), b) high and moderate-high LOP, and c) all levels of protection. In addition to providing recreational opportunities, these parks also provide one or more educational opportunities.

Evaluation of educational and study opportunities focuses on:

- *Major marine research and educational institutions within given distances of proposed MPAs.* The evaluation is limited to the major research and educational institutions in the region, of which there are 49 in total. These institutions include: aquariums, research and educational institutions, education-only institutions, and research-only institutions. For this parameter, it is determined how many institutions are within 15 miles or within 15-50 miles of proposed MPAs by the following level of protections: a) very high, b) high and moderate-high, and c) all levels of protection.

- *California State Parks (with educational components) located adjacent to proposed MPAs.* There are thirty-two state parks located on the coast adjacent to the Pacific Ocean in the south coast study region. State parks will be counted if they intersect (are adjacent to) onshore MPAs and their associated boundaries. This parameter is evaluated for proposed MPAs with: a) very high level of protection (LOP), b) high and moderate-high LOP, and c) all levels of protection. These parks also provide one or more recreational opportunities.
- *Long-term marine research monitoring sites located within proposed MPAs*. This parameter considers the key, long-term monitoring sites in the study region and includes nearly 1,400 sites. This parameter is evaluated for the number of monitoring sites located within proposed MPAs with: a) very high level of protection, b) high and moderate-high LOP, and c) all levels of protection.
- *Replication of habitats within the study region.* There are sixteen habitats under consideration and they include: sandy beaches, rocky shore, surfgrass, soft substrate (0-30 m), soft substrate (30-100 m), soft substrate (100-200 m), soft substrate (200-3000 m), hard substrate (0-30 m), hard substrate (30-100 m), hard substrate (100-200 m), hard substrate (200-3000 m), kelp, estuary, coastal marsh, tidal flats, and eelgrass. A habitat is considered to be present within an MPA if at least a critical amount of that habitat is present, based on the SAT evaluation methods. The number of habitat replicates is counted within an MPA proposal. Habitat replication will be considered for proposed MPAs at a) very high, b) high or moderate-high level of protection, and c) all levels of protection.

12. Commerical and Recreational Fishery Impacts

Status of this chapter: The SAT has approved of the methods in this chapter

While fishery impacts are not the focus of the MLPA, they may be considered in designing alternative MPA proposals. The evaluation of maximum potential recreational and commercial fishery impacts utilizes region-specific data collected by MLPA contractor Ecotrust on areas of importance.

To evaluate the potential recreational and commercial fishery impacts, MLPA Initiative staff and contractors do the following:

- conduct local knowledge interviews with recreational and commercial fishermen, using an interactive, custom computer interface, to collect geo-referenced information about the extent and relative importance of study region commercial and recreational fisheries
- organize impact analyses by port, fishery and/or user group
- evaluate and summarize the maximum potential impacts on commercial and recreational fishing grounds both in terms of total area and value affected, with results summarized for both study region fishing grounds and total fishing grounds[27]
- conduct a socioeconomic impact analysis for commercial fisheries
- consider or identify “outliers” (i.e. fishermen likely to experience disproportional impacts)
- assess the effect of existing fishery management area closures and other constraints on fishing grounds

Background

In order to conduct an analysis of the relative effects of MPA proposals on commercial fisheries that are conducted in the South Coast Study Region (SCSR), we use data layers characterizing the spatial extent and relative stated importance of fishing grounds for key commercial fisheries. This information was collected during interviews in the summer of 2008, using a stratified, representative sample of 254 commercial fishermen whose individual responses regarding the relative importance of ocean areas for each fishery were standardized using a 100-point scale and normalized to the reported fishing grounds for each fishery.

In addition, we conduct an assessment of the relative effects of MPA proposals on key recreational fisheries conducted in the waters in the SCSR. In order to complete this analysis we use data layers characterizing the spatial extent and relative stated importance of recreational fishing grounds for key recreational fisheries. Recreational fishermen are also broken out by user group (i.e. commercial passenger fishing vessels, private vessels, kayak,

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[27] Impact analyses represent a “worst case” scenario in which fisherman cannot fish in a different location.

pier/shore and dive). This information was collected during interviews in the summer of 2008 from 119 commercial passenger fishing vessel (CPFV) operators and 504 recreational fishermen whose individual responses regarding the relative importance of ocean areas for each fishery were standardized using a 100-point scale and normalized to the reported fishing grounds for each fishery.

Using the normalized data described above, we 1) evaluate the potential impacts on the commercial and recreational fishing grounds and 2) conduct a socioeconomic impact analysis on commercial fisheries in order to assess the potential effects of any MPA proposal. Results are reported at both the study region and port group levels for the commercial fisheries. Port groups are defined as (from north to south) Santa Barbara, Ventura, Port Hueneme/Channel Islands, San Pedro, Dana Point, Oceanside, and San Diego. Recreational fishery results are reported by user group. Similarly, we report CPFV impacts by the following port/landing groups: Santa Barbara, Port Hueneme/Channel Islands, Santa Monica, San Pedro/Long Beach, Newport Beach, Dana Point, Oceanside, San Diego. Recreational impacts will be reported both by user group and by county (i.e. Santa Barbara, Ventura, Los Angeles, Orange, and San Diego).

It should be noted that, with respect to the recreational fishery analysis, the use of a stratified solicited sample limits the use of traditional statistical measures—for example, confidence intervals—meaning they may not deliver their advertised precision. Nevertheless, this approach does allow us to make broad generalizations about preferences of the overall recreational fishing population and the five user groups within the study area, adding increased thematic resolution to the MLPA decision-making process.

Impact on Commercial Fishing Grounds: Methods

Marine protected area (MPA) proposals typically vary according to their spatial extent and the commercial fisheries they affect. More specifically, MPAs often vary by the number and types of fisheries permitted within the boundaries of particular MPAs. Furthermore, study area fisheries themselves vary in spatial extent, and frequently overlap. Many of them are conducted in fishing grounds that extend beyond the state waters of the SCSR, and because of this we report potential impacts both in terms of total fishing grounds and those that fall within the study area (i.e. zero to three nautical miles from shore). Since any one MPA may have different effects on different fisheries, and different fisheries may be affected differently by all MPAs, it is necessary to consider single MPAs and single fishery uses independently. Note that because current fishery closures affect all proposals equally, they have no differential effect.

A key assumption of this analysis is that each of the MPA proposals completely eliminates fishing opportunities in areas closed to specific fisheries and that fishermen are unable to adjust or mitigate in any way. In other words, the analysis assumes that all commercial fishing in an area affected by an MPA would be lost completely, when in reality it is more likely that effort would shift to areas outside the MPA. The effect of such an assumption is most likely an overestimation of the impacts, or a “worst case scenario.”

We conduct an overlay of each MPA with each fishery considered in this study. MPAs are grouped according to level of protection, using the same levels of protection as elsewhere in the SAT evaluations. In other words, for each MPA and protection level within each proposal, we assess the commercial fisheries that would be affected.

We compile results in a series of spreadsheets, summarizing the effects of the various MPA proposals on commercial fisheries, both in terms of the area affected and the relative value lost. We use the same analytical methods as those developed and used in previous iterations of the MLPA process (see Scholz et al. 2008 and Scholz et al. 2006), creating a weighted surface that represents the stated importance of different areas for each fishery. More specifically, we multiply these stated importance values by the proportion of in-study region landings (by landing port and by fishery). The percentage of area and value affected is calculated based on grounds identified within only the SCSR and not within the whole state of California. These estimates then feed into the economic impact assessment (described in more detail in Appendix C).

The percentage change in area and value for each of the commercial fisheries (both for the study region and for each port group) are determined by the intersection of each MPA proposal and the fishing grounds specific to that fishery. Each MPA within a proposal is classified by whether it would affect the fishery or not. If a fishery is affected by an MPA, the area and value are summarized and then divided by the total area and value for the entire fishing grounds as derived from interviews with fishermen, and the total study area. The total percentage of area and value affected for the total fishing grounds and the grounds inside the study area are then summarized for all MPAs affecting each fishery per proposal.

For the commercial fisheries, we evaluate the additional impacts that potentially occur when considering the existing fishery management area closures and/or fishery exclusion zones.

The fishing grounds, as defined by the fishermen through the interview process, represent the total area and value regardless of these existing or potential fishery management closures and/or fishery exclusion zones. In order to evaluate the effect of such closures, the fishing grounds that fall inside those areas are removed, and the value associated with the removed area redistributed to the remaining fishing grounds outside the closed areas. In other words, values are redistributed across only what could be considered the available fishing grounds in proportion to their relative value as derived from the interviews. Using the same method described above, we determine the percentage change in value by the intersection of each MPA proposal with the total fishing grounds now constrained to areas not inside the closed areas, i.e., the “available fishing grounds”.

We also evaluate if there are individual fishermen who would be disproportionally affected by each MPA proposal (i.e. 100% or a large portion of their grounds are inside a proposed MPA that would restrict fishing). To assess this impact we conduct an analysis that removed the area of each proposed MPA from an individual fisherman’s fishing grounds as derived from interviews. The individual’s SCSR ex-vessel revenue and area of the fishing grounds are then summarized after the removal and percentages are calculated to show any potential losses. The "worst-cast scenario" still applies in that individual fishermen are assumed not to adjust to different fishing grounds. For this analysis the potential impact was calculated for each fishery as well as for all fisheries in which an individual participates.

Commercial Fisheries Economic Impact Assessment

The primary purpose of this analysis is to estimate the socioeconomic impacts to the commercial fishery sector associated with each of the MPA proposals. To accomplish this, we estimate a "worst-case scenario" or maximum potential economic impact of each MPA proposal (for a detailed description of the methods used, please see Scholz et al. 2008, which can be found at http://www.ecotrust.org/mlpa/Ecotrust_FinalReport_NCCSR_080701.pdf). To accomplish this, we use methods similar to those utilized in the Central Coast Study Region process by Wilen and Abbott (2006). The modified analysis in Scholz et al. (2007), however, differs in a very important respect, that is, by having original survey data on fishermen's operating costs collected through the interview process.

As mentioned previously, this refinement is possible due to new data gathered during the interview process on fishery specific operating costs in the study area. As part of the fishermen interview process, field staff asked several questions related to operating costs, including:

- What percentage of your gross revenue goes towards overall operating costs?
- Of your overall operating costs, what percentage goes towards crew share or labor?
- Of your overall operating costs, what percentage goes towards fuel?

With the opportunity to interview SCSR fishermen directly, information specific to the study region is gained. There is also the opportunity for data resolution regarding types of costs fishermen face. Using data from the fishermen knowledge interviews, two cost categories were created: fixed and variable. Fixed costs include costs that are independent of the number of trips a fishing vessel makes or the duration of these trips. For example, vessel repairs and maintenance, insurance, mooring and dockage fees are typically considered fixed costs. On the other hand, variable costs include costs that are dependent on the number of trips a vessel makes and the duration of these trips. Variable costs typically include fuel, maintenance, crew share, and gear repair/replacement. For the purpose of this study, variable costs are assumed to be crew wages and fuel costs. All other costs will be considered fixed costs.

The net economic impact (NEI) of each MPA proposal is calculated for each port group, and for the SCSR as a whole. The NEI results are presented as revenue reductions in both dollar terms ($ 2007) and percentage terms. The starting point for calculating NEI is baseline gross economic revenue (Baseline GER), which is based on an 8-year average (2000–07) converted to 2007 dollars. Baseline GER is gross revenue for the fishery in question absent any MPA proposal. The baseline net economic revenue (Baseline NER) is found by subtracting the fishery-specific fixed and variable costs from the Baseline GER. A similar net economic revenue calculation is performed for each MPA proposal and is then compared with Baseline NER to yield NEI.

Impact on Recreational Fishing Grounds: Methods and Approach

The methods and approach used to assess the impact of the various MPA proposals on recreational fisheries are identical to those used to assess the impact on commercial fisheries (please refer to Appendix C of this document for a description of those methods) with one exception. The commercial fishery impact analysis assesses fishing grounds that are weighted by multiplying stated importance values from the interviews by the proportion of in-study region landings (both by landing port and by fishery), and more specifically, by ex-vessel values for those landings. In contrast, no weighting occurs in the calculation of recreational fishing grounds, but rather, the analysis is done using only stated importance values from the interviews. No weighting occurs for the obvious reason that ex-vessel values do not exist for recreational fishery landings. Again, we report CPFV impacts by the following port/landing groups: Santa Barbara, Port Hueneme/Channel Islands, Santa Monica, San Pedro/Long Beach, Newport Beach, Dana Point, Oceanside, and San Diego. Recreational impacts will be reported both by user group and by county (i.e. Santa Barbara, Ventura, Los Angeles, Orange, and San Diego).

The recreational data presented here should be used with the following caveats:

- The data are not representative of the entire population of recreational fishermen due to the less than desirable (less than statistically significant) sample size (CPFV not included).
- The data should only be considered at the county or port/landing level, not at the entire study region level.
- The data represents interviewees' areas of value, not areas of effort.
- The data represents interviewees' areas that are important to them over their entire recreational fishing experience, not necessarily the areas that are important to them currently.

That said, based on conversations with leaders of the recreational fishing community, we believe that the information and the manner in which it was acquired allows us to produce results that are able to speak broadly to both the preferences of the overall recreational fishing population and also each user group and county or port/landing of anglers.

As in the commercial fisheries impact analysis, the percentage change in area and value for each of the recreational fisheries (only for the county or port/landing) are determined by the intersection of each MPA proposal and the fishing grounds specific to that fishery.

REFERENCES

- Scholz, A., Steinback, C. and Mertens, M. (2006). Commercial fishing grounds and their relative importance off the Central Coast of California. Report submitted to the California Marine Life Protection Act Initiative (May 4, 2006).
- Scholz, A., Steinback, C., Kruse, S., Mertens, M., and Weber, M. (2008). Commercial and recreational fishing grounds and their relative importance off the North Central Coast of California. Report submitted to the California Marine Life Protection Act Initiative (June 30, 2008).

Appendix A. Levels of Protection for Potential Allowed Uses

This appendix shows all potential allowed usages for which the SAT has completed its analysis using the decision process given in chapter 3.

In applying the conceptual model presented in Figure 3-1, Table A-1 provides a decision matrix for some sample activities and the corresponding level of protection designated in Table 3-1. Table A-1 and Figure 3-1 should be viewed together to follow the decision pathway.

In Table A-1, colors across the top row correspond to the question level in the conceptual model in Figure 3-1, N/A indicates that question was not addressed following the decision flow.

Table A-1. Level of Protection Decision Matrix

Question Level→		1	2		3		4	
Allowed Use	LOP Desig-nation	Does proposed activity alter habitat directly?	Is abundance of any species likely to be significantly different in the MPA relative to an SMR?	Is habitat alteration likely to change community structure substantially?	Is removal of any species likely to impact community structure directly or indirectly?	Is removal of any species likely to directly alter habitat?	Is habitat alteration caused by species removal likely to change community structure substantially?	Is the altered abundance of any species likely to alter community structure substantially?
barred sand bass (H&L or spear)	mod-low	NO	YES - target species has low movement & MPA effect has been shown	N/A	N/A	NO	N/A	YES - important predator
cabezon (H&L, spear)	high	NO	YES - target species has low movement, incidental catch includes other low mobility reef species	N/A	N/A	NO	N/A	YES - cabezon are important predators
catch and release (H&L barbless single hooks, and artificial lures only) in shallow <10m water or using surface gear	mod-high	NO	NO - likely low hooking mortality for most species using barbless single hooks with artificial lures (which result in fewer gut hookings), barotrauma unlikely in shallow waters (<10m), in estuarine environments unpublished data from LA shows a high tag return rate for spotted sandbass which indicates small populations and good survival rate	N/A	YES - sensitivity to handling varies by species, although we expect most species to have a high survival rate with proper handling, some species may be impacted by this catch and release fishing and thus impact community structure relative to an SMR	N/A	N/A	N/A
catch and release (H&L) in open coast environments >10m depth	mod-low	NO	YES - likelihood of barotrauma and mortality increases with depth	N/A	N/A	NO	N/A	YES - many removed species are important predators

	Question Level→	1	2		3		4	
Allowed Use	LOP Desig-nation	Does proposed activity alter habitat directly?	Is abundance of any species likely to be significantly different in the MPA relative to an SMR?	Is habitat alteration likely to change community structure substantially?	Is removal of any species likely to impact community structure directly or indirectly?	Is removal of any species likely to directly alter habitat?	Is habitat alteration caused by species removal likely to change community structure substantially?	Is the altered abundance of any species likely to alter community structure substantially?
clams (hand harvest)	moderate	NO - dynamic soft-bottom is not highly sensitive to this disturbance	YES - clams don't move around much, maybe some incidental take or death of other sessile marine invertebrates	N/A	N/A	NO	N/A	NO - clams are an important food source for many fish and elasmobranchs, but hand harvest only occurs in the intertidal zone (a small portion of the depth distribution of clams) thus the impact of harvest on community structure is likely to be limited
coastal pelagic finfish* and bonito (seine, dip-net, crowder)	high	NO - bottom contact does occur with seine gear, but infrequently	NO - target species are highly mobile, incidental catch is comprised primarily of other highly mobile species	N/A	NO - target species are highly mobile and low incidental catch of resident species	N/A	N/A	N/A
giant kelp (hand harvest)	moderate	NO - doesn't damage the substrate, per se	YES - kelp doesn't move			YES - kelp canopy FORMS habitat (notably for the juveniles of commercialy important fish), so removing it removes habitat	NO - under current technology and spatial harvest methods, hand harvest results in only patchy removal of surface kelp canopy which likely does not substantially alter community structure	

	Question Level→	1	2		3		4	
Allowed Use	LOP Desig-nation	Does proposed activity alter habitat directly?	Is abundance of any species likely to be significantly different in the MPA relative to an SMR?	Is habitat alteration likely to change community structure substantially?	Is removal of any species likely to impact community structure directly or indirectly?	Is removal of any species likely to directly alter habitat?	Is habitat alteration caused by species removal likely to change community structure substantially?	Is the altered abundance of any species likely to alter community structure substantially?
giant kelp (mechanical harvest)	low	NO - doesn't damage the substrate, per se	YES - kelp doesn't move	N/A	N/A	YES - kelp canopy FORMS habitat (notably for the juveniles of commercialy important fish), so removing it removes habitat	YES - kelp provides structure for a rich and unique community, removal by mechanical harvest extends deeper than hand harvest and removes broad swaths of canopy, changing community structure substantially	N/A
grunion (hand take)	moderate	NO	YES - genetics suggest highly mobile, but likely breeding site fidelity	N/A	N/A	NO	N/A	NO - eggs are a source of food on breeding beaches
halibut (H&L)	high	NO	YES - halibut move moderate to long distances, incidental catch includes resident species (e.g. barred sand bass)	N/A	N/A	NO	N/A	YES - resident species caught in association with halibut are important predators and their removal is likely to influence community structure
halibut (spear)	mod-low	NO	NO - halibut move moderate to long distances so abundance is unlikely to change relative to an SMR, spear fishing is likely to have low incidental catch	N/A	N/A	NO	N/A	YES - halibut are important predators in benthic ecosystem, any change in abundance could have impacts on community structure

Question Level→		1	2		3		4	
Allowed Use	LOP Desig-nation	Does proposed activity alter habitat directly?	Is abundance of any species likely to be significantly different in the MPA relative to an SMR?	Is habitat alteration likely to change community structure substantially?	Is removal of any species likely to impact community structure directly or indirectly?	Is removal of any species likely to directly alter habitat?	Is habitat alteration caused by species removal likely to change community structure substantially?	Is the altered abundance of any species likely to alter community structure substantially?
jumbo squid (squid jigs/ drift)	high	NO	NO - jumbo squid are highly mobile, incidental catch is low due to use of squid jigs which do not readily capture other species	N/A	NO - jumbo squid are highly mobile and low incidental catch of resident species	N/A	N/A	N/A
Kellet's whelk (trap)	mod-low	NO	YES - target species has low movement & MPA effect has been shown	N/A	N/A	NO	N/A	YES - important benthic predator, especially on grazers and thus may have indirect effects on kelp abundance and associated community
kelp bass (H&L or spear)	mod-low	NO	YES - target species has low movement & MPA effect has been shown	N/A	N/A	NO	N/A	YES - impt predator
lingcod (H&L, spear)	mod-low	NO	YES - target species has low movement, incidental catch includes other low mobility reef species	N/A	N/A	NO	N/A	YES - lingcod are important predators in nearshore rocky reef
lobster (trap, hoop net, scuba)	mod-low	NO - gear contacts bottom but habitat damage unlikely	YES - target species has low movement & MPA effect has been shown	N/A	N/A	NO	N/A	YES - important urchin predator and thus may have indirect effects on kelp and associated community

Question Level→		1	2		3		4	
Allowed Use	LOP Desig-nation	Does proposed activity alter habitat directly?	Is abundance of any species likely to be significantly different in the MPA relative to an SMR?	Is habitat alteration likely to change community structure substantially?	Is removal of any species likely to impact community structure directly or indirectly?	Is removal of any species likely to directly alter habitat?	Is habitat alteration caused by species removal likely to change community structure substantially?	Is the altered abundance of any species likely to alter community structure substantially?
marine algae other than giant and bull kelp (hand harvest)	low	NO - doesn't damage the substrate, per se	YES - marine algae doesn't move	N/A	N/A	YES - all marine algae FORM habitat, so removing it removes habitat	YES - marine algae provide structure for a rich and unique community, removal has the potential to change community structure substantially	N/A
mussels (hand harvest)	low	NO - doesn't damage the substrate, per se	YES - mussels are sessile	N/A	N/A	YES - mussels FORM habitat, so removing them removes the habitat	YES - mussel beds are associated with a unique community, removing them changes community structure	N/A
pelagic finfish*, white seabass, and bonito (H&L) <30m depth on mainland and <50m depth at islands	mod-low	NO	YES - target species are highly mobile, incidental catch of resident benthic species (kelp bass on rocky reef and barred sand bass on soft bottom) is very likely in shallow water	N/A	N/A	NO	N/A	YES - incidentally caught resident species play an important predatory role in the nearshore environment
pelagic finfish*, white seabass, and bonito (H&L) >50m depth	high	NO	NO - target species are highly mobile, incidental catch of resident species is likely to be low deeper than 50m where no kelp occurs	N/A	NO - target species are highly mobile and low incidental catch	N/A	N/A	N/A
pelagic finfish*, white seabass, and bonito (H&L) 50>30m depth using surface gear on mainland	mod-high	NO	NO - target species are highly mobile, incidental catch of resident species is likely to be moderate as you fish closer to kelp beds	N/A	YES - incidental catch of resident benthic species could change community structure	N/A	N/A	N/A

Question Level→		1	2		3		4	
Allowed Use	LOP Desig-nation	Does proposed activity alter habitat directly?	Is abundance of any species likely to be significantly different in the MPA relative to an SMR?	Is habitat alteration likely to change community structure substantially?	Is removal of any species likely to impact community structure directly or indirectly?	Is removal of any species likely to directly alter habitat?	Is habitat alteration caused by species removal likely to change community structure substantially?	Is the altered abundance of any species likely to alter community structure substantially?
pelagic finfish*, white seabass, and bonito (spear)	high	NO	NO - target species are highly mobile, selective harvest by spear should result in little or no incidental catch	N/A	NO - target species are highly mobile and low incidental catch	N/A	N/A	N/A
pier-based fishing (H&L, hoop net)	mod-high	NO	NO - most H&L catch is highly mobile species, especially coastal pelagics but some catch of less mobile croaker (8%), surfperch (7%) , and basses (3%), small hoop net catch of lobsters.	N/A	YES - a few resident species are caught from piers and this could have an impact on community structure	N/A	N/A	N/A
rock crab (trap)	mod-low	NO - bottom contact occurs but damage unlikely	YES - yellow crabs and brown rock crabs likely have a limited home range, several tagging studies show that individuals stay in the same area for months to 1 year while others may participate in migrations on the order of 10km.	N/A	N/A	NO	N/A	YES - important predators and scavengers (predators of small urchins) and thus take likely to impact community structure
rock scallop (scuba)	low	YES	N/A	YES - rock scallop removal modifies rugosity of reef and local diversity of benthic species	N/A	N/A	N/A	N/A

	Question Level→	1	2		3		4	
Allowed Use	LOP Desig-nation	Does proposed activity alter habitat directly?	Is abundance of any species likely to be significantly different in the MPA relative to an SMR?	Is habitat alteration likely to change community structure substantially?	Is removal of any species likely to impact community structure directly or indirectly?	Is removal of any species likely to directly alter habitat?	Is habitat alteration caused by species removal likely to change community structure substantially?	Is the altered abundance of any species likely to alter community structure substantially?
rockfish (H&L, spear)	mod-low	NO	YES - target species have low movement, incidental catch includes other low mobility reef species	N/A	N/A	NO	N/A	YES - rockfish are important predators in nearshore rocky reef
sea cucumber (scuba/hookah)	moderate	NO	YES - target species abundance and size shown to decrease where not protected	N/A		NO		NO - detritivore and prey
sheephead (H&L, spear, trap)	mod-low	NO - traps contact bottom but habitat damage unlikely	YES - target species has low movement & MPA effect has been shown	N/A		NO		YES - impt urchin predator
shore-based finfish (H&L)	mod-low	NO	YES - a wide range of species may be caught from shore--some have limited depth distribution or special breeding habits that make them vulnerable to fishing from shore--catch includes resident estuarine species (spotted sandbass, juvenile halibut), resident rocky reef species (opaleye, kelp bass, rockfish, sheephead), and surf-zone species (breeding surfperch).	N/A		NO		YES - many removed species are important predators in nearshore evironments.

	Question Level→	1	2		3		4	
Allowed Use	LOP Desig-nation	Does proposed activity alter habitat directly?	Is abundance of any species likely to be significantly different in the MPA relative to an SMR?	Is habitat alteration likely to change community structure substantially?	Is removal of any species likely to impact community structure directly or indirectly?	Is removal of any species likely to directly alter habitat?	Is habitat alteration caused by species removal likely to change community structure substantially?	Is the altered abundance of any species likely to alter community structure substantially?
spot prawn (trap)	moderate	NO - traps contact bottom but habitat damage unlikely	YES - genetics and parasites suggest low movement in BC, no studies from CA	N/A	N/A	NO	N/A	NO - predator and prey
spotted sand bass (H&L)	mod-low	NO	YES - target species has low movement, restricted to estuaries	N/A	N/A	NO		YES - impt predator in estuarine embayments
squid (seine, dip-net, crowder)	high	NO - bottom contact does occur with seine gear, but infrequently	NO - target species are highly mobile, incidental catch is comprised primarily of other highly mobile species	N/A	NO - target species are highly mobile and low incidental catch of resident species	N/A	N/A	N/A
swordfish (harpoon)	high	NO	NO - swordfish are highly mobile and harpoon fishing requires visual contact, thus low incidental catch	N/A	NO - highly mobile	N/A	N/A	N/A
urchin (scuba/hookah)	mod-low	NO	YES - target species has low movement	N/A	N/A	NO	N/A	YES - impt grazer of kelp which can change the entire structure of ecosystem

Appendix B. Bioeconomic Modeling

B1. Model Assumptions for Key Structural Elements in Spatially Explicit Bioeconomic Models

Table B1-1. Assumptions of the UCD and UCSB Bioeconomic Models

UCD Model Assumptions	UCSB Model Assumptions
Larval Dispersal: Adults of representative species in each 1 km x 1 km habitat cell throughout the study region spawn larvae that are randomly distributed within that cell. The probability of larvae moving from that cell to any other in the study region is calculated using output from the ROMS model, for which larvae are assumed to behave as passive, neutrally buoyant particles. Dispersal pathways are calculated by averaging across seven years of ROMS circulation output (1996-2002). This is may be modified, as needed, pending analysis of the sensitivity of model results to time-varying dispersal kernels. For each species, dispersal pathways are calculated using known spawning seasons and pelagic larval durations for the species. ROMS dispersal probabilities are calculated for five km radius circles distributed along the coastline of the study region; these data are mapped onto the 1 km x 1 km habitat grid used in the population models. Successful settlement for larvae 'arriving' at each model cell is contingent on the presence of suitable habitat in that cell.	**Larval Dispersal:** Same as UCD model.
Larval Settlement: Settling larvae experience intra-cohort density-dependent mortality. That is, the mortality rate of settlers depends on the density (fish per square meter) of other settlers arriving at that location, reflecting competition for habitat and predator refuges that is typical of the species being modeled.	**Larval Settlement:** Settling larvae experience intra-cohort density-dependent mortality as in the UCD model. Because this density-dependence represents competition for habitat and refuges, its strength depends on the proportion of the cell that is suitable habitat. For a given number of settling larvae, more will survive to adulthood in a cell with abundant suitable habitat than will survive in a cell with mostly poor habitat.
Adult Growth and Reproduction: Growth, survival, and egg production are based on published data. In general, individuals grow to a maximum length, their weight is proportional to length cubed, and egg production is proportional to weight. Thus old, large individuals produce more eggs than young small individuals. Survival	**Adult Growth and Reproduction:** Growth for each species is based on previously published growth curves. Survival is independent of fish age and is based on published estimates of mortality in the absence of fishing. Egg production is assumed to be proportional to the total weight of adult fish.

UCD Model Assumptions	UCSB Model Assumptions
is constant with age except for species for which more precise data are available.	
Adult Movement: Adults move within home ranges. Individuals with home ranges spanning MPA boundaries experience fishing pressure in proportion to the amount of their home range that is outside the MPA. This creates a spillover effect for adults with home ranges centered just inside MPAs.	**Adult Movement:** Two types of movement are modeled: irreversible movement of fish into a new home range and movement within a fixed home range. Irreversible movements are assumed to be relatively rare, but sometimes quite large (10-20 km alongshore). Movement within home ranges means that the “exploitable biomass” within a cell is a sum of contributions from fish with home ranges centered in the cell and in surrounding areas.
Fishing Pressure: Fishing regulations follow those set forth in each draft proposal, and both recreational and commercial fishing are considered. Initially, in the absence of better information, fishing effort will be modeled assuming that effort is equal across space but total effort is redistributed and increases outside of MPAs after MPA implementation. Pending collaboration with UCSB and Ecotrust, fishing effort will vary over space depending on fish abundance and travel costs (distance from port) using a fleet model that is parameterized based on data from the southern California commercial fishing fleet.	**Fishing Pressure:** We assume that fishers are acting to maximize their own profits. Assuming a large number of fishers acting independently, this means that fishing effort will be distributed such that at the end of each season marginal profits are the same in all patches. The current calculation of profits accounts for the “stock effect” in which fish are cheaper to extract from large than from small populations. We are working on incorporating costs of travel and weather into the model, which will reduce profits in more distant and less sheltered locations. We are collaborating with UCD and Ecotrust to parameterize the fleet model using data on fishing effort and profit, by location.

B2. Summary of Methods for Parameterizing Fishing Fleet Component of Spatially Explicit Bioeconomic Models

Note: These methods are currently under development.

Both the economic and conservation outcomes of implementing an MPA network will depend on how areas outside of the MPAs are fished. The UCSB and UCD models therefore predict not only how MPAs will change fish populations but also how fishing effort will be distributed throughout the region. Because of the broad spatial scale and the large number of fishers involved, the models do not seek to predict decisions made by individual fishers but instead to predict the aggregate distribution of fishing effort for each species.

The description of the spatial distribution of fishing effort in the bioeconomic models can take on several forms, of increasing complexity. The simplest description is a uniform distribution of effort (except in MPAs, where effort is restricted or prohibited). A somewhat more realistic description is to allow fishing effort to be redistributed across space as a function of profit. This approach is based on the expectation that effort on each species will be distributed across patches so that marginal profits from fishing the species are the same in all fished patches. If this were not the case, and one patch had higher marginal profits than another, fishers would be expected to reduce effort in the less profitable patch and allocate more effort to the more profitable patch. To calculate the level of fishing effort that equalizes marginal profits in each patch, the models need to know how profit in each patch varies as a function of fishing effort.

Profit in each patch is calculated as revenue less costs, where revenue is a function of fishing effort and fish biomass in the patch, and costs are a function of fishing effort in the patch, distance of the patch from the nearest port and typical weather conditions in the patch. A simple form is assumed for this relationship:

Profit in patch $i = \alpha_1 f(E_i, B_{i0}) - [\alpha_2 D_i + \alpha_3 W_i + \alpha_4]\, E_i$

Where $f(E_i, B_{i0})$ gives yield as a function of effort and biomass in patch i, D_i is the distance of the patch from port, W_i reflects typical weather conditions in the patch, and the α terms are unknown parameters giving the relative importance of the different factors.

The modeling team is collaborating with Ecotrust to determine the values of these α parameters. For each species, the α parameters are tuned to obtain the best match between the spatial distribution of fishing effort predicted by the model (assuming the current suite of existing MPAs) and the actual current distribution of fishing, documented by Ecotrust. These best parameter values will then be used in evaluating alternative MPA proposals, and will allow the models to predict how fishing effort will be distributed under that proposal, and thus how fishing outside of MPAs will effect conservation and economic outcomes of the proposal.

Note that while “profit” implies the sale of harvested resources, it is possible to calculate the relative benefit of recreational fishing in each location in an analogous manner because recreational fishermen place a value, though not necessarily monetary, on the fish they catch.

B3. Summary of Life History Parameters Used in Models

Life-history parameters for each modeled species were obtained by searching the published scientific literature, stock assessments, and the 2000 Pacific States Marine Fisheries Commission report prepared by G. Cailliet et al. At present this appendix describes parameters obtained and used by the UC Davis model; there is an ongoing collaboration between the UC Davis and UCSB groups to double-check and revise (as necessary) these estimates. Some parameters are still tentative pending contact with various experts who may possess unpublished data. Furthermore, the modeling groups will circulate this document among appropriate scientific experts, including those on the SAT, to confirm the accuracy of these estimates. Therefore some values may be revised as the south coast process progresses.

Parameters Used

Movement: Because management with MPAs involves creating differences in conditions (i.e., fishing mortality rate) over space, the effects of individual movement have a critical effect on sustainability and yield. Two kinds of biological movement are important, dispersal during the larval stage and swimming movement during juvenile and adult stages.

Juvenile/Adult Swimming: Most of the species that will be protected and sustained by the MLPA either have very little adult movement, or move within a specified home range. For some of these species the sizes of the home ranges have been estimated using acoustic tags. This type of movement can be considered well known for species that have been studied in this way. In general, home range size is reported in terms of diameter, which facilitates implementation in a one-dimensional model. There is greater confidence in estimates derived from acoustic tagging studies than from simple tag-recapture studies.

Larval Dispersal: The models use estimates of larval dispersal derived from the ROMS-based Lagrangian particle-tracking model developed by UCLA and UCSB. In this approach, each species is characterized by pelagic larval duration (PLD) and spawning season.

Life History: Both reproduction and yield depend on the sizes of individuals, which depends on how fast they grow through life. Here size vs. age is presented in terms of the dependence of length on age in the most commonly used form, a von Bertalanffy growth function. The parameter L_∞ represents the mean length for very old individuals, the parameter k represents the growth rate at young ages, and the parameter t_0 essentially describes the length of an individual at age 0. Size vs. age is also presented in terms of weight, which is calculated from size via an allometric relationship, $W = aL^b$. The values of a and b are given for each species.

Reproduction depends on the age of maturity and fecundity. Fecundity, f, the number of eggs produced by a female of a certain age or size in a year, is commonly assumed to be proportional to weight, but is sometimes also calculated from an allometric (or other) relationship with length.

Mortality consists of two components, fishing mortality and natural mortality. Here is presented instantaneous mortality rates.

The size ranges that are available to be caught by the fishery are either specified by regulation or estimated from fishery or other data.

Compensation Ratio / Critical Replacement Threshold: Species persistence, and thus all model results, depend heavily on the shape of the settler-recruit relationship. This relationship describes the per-capita mortality of settlers as a function of settler density; settlers surviving this initial bout of post-settlement mortality are considered ‘recruits’ into the benthic population. This curve is generally described in terms of the slope at the origin; it is assumed that the curve has a Beverton-Holt functional form and that the asymptotic maximum density can be made nondimensional by scaling all model results to the baseline unfished case.

The settler-recruit curve is analogous to the stock-recruit curves utilized in nospatial fishery models. The slope at the origin of the stock-recruit curve can be described as a nondimensional compensation ratio, which is the ratio of per-capita settler survival at very low densities (settlers = 0) to per-capita survival of settlers at the highest possible density in the unfished state. The inverse of this number (1/CR) is also referred to as the critical replacement threshold (CRT), because it is the fraction of lifetime egg production (FLEP) below which the population is not persistent. That is, if CR = 5, CRT = 1/5 = 0.2, and if fishing reduces lifetime egg production below 20% of its unfished maximum, the population will collapse. Estimates of the CR are generally difficult to obtain except for species that have been fished below the CRT and therefore collapsed. As a consequence the CR is known for only a few fished species. Dorn (2002) estimated a CR of approximately 3 for several collapsed species of north Pacific rockfishes. This CR is likely to be a conservative estimate, especially since some southern California species are likely to be somewhat more resilient than those rockfish species. Therefore, both models use a reasonable but nonetheless conservative estimate of CR = 4 (CRT = 0.25) for the settler-recruit curves for each species.

Although the choice of CR will affect the model results, by far the largest effect will be on the sensitivity of the population to fishing. This effect on sensitivity to fishing should largely be accounted for by the methods used to choose fishing effort outside of reserves. Because fishing effort in each of the future fishing scenarios is chosen as some constant fraction of CRT (or MSY, in the case of the UCSB model), the potential for the choice of CR to affect model outcomes should be much reduced.

Species Notes

At this time the effects of alternative MPA proposals are evaluated for 8 species. The text and tables that follow provide both reported estimates of each parameter and, for those parameters with different estimates or a range of values, an indication of the value chosen to use in the models. Unless otherwise noted, all distances are in kilometers, all organisms lengths are in centimeters, and all masses are in kilograms.

Kelp bass (*Paralabrax clathratus*)*

The estimate of home range size is based on acoustic telemetry studies (Lowe et al. 2003). The estimate of < 1 km actually encompasses some rare longer-distance movements, as most fish use home ranges smaller than this estimate.

California Sheephead (*Semicossyphus pulcher*)*

The estimate of home range size is based on acoustic telemetry studies (Topping et al. 2005, 2006). The same authors also suggests that sheephead prefer ecotone habitat that spans both sand and rocky reef.

Kelp rockfish (*Sebastes atrovirens*)*

The estimate of home range size is based on tag-recapture studies (Miller and Geibel 1973, Lea et al. 1999). Computer simulations suggest that home range diameter is approximately 70% of the mean recapture distance in tag-recapture studies.

Ocean Whitefish (*Caulolatilus princeps*)

The estimate of home range size is based on acoustic telemetry studies (Bellquist et al. 2008).

Fishing for ocean whitefish is primarily recreational, although there may be some bycatch in the live fish fishery (CDFG 2003). The status of the fishery is essentially unknown because it is widely assumed that larval fish settle in Mexico and eventually migrate to California waters as adults (CDFG 2003). However, coastal benthic trawl surveys in 1969-1999 found that whitefish recruitment does occur in California waters, primarily in warmer years (Bellquist et al. 2008).

Opaleye (*Girella nigricans*)

No home range data are available for non-tidepool individuals; still checking citations in Davis (2001). PLD is 2-4 months (Waples 1987 Evolution).

Black perch (*Embiotoca jacksoni*)

The estimate of home range size is based on tagging studies conducted by Hixon (1979, 1980).

No larval stage.

Red sea urchin (*Strongylocentrotus franciscanus*)*

There are several references for the duration of the larval stage of red sea urchin; the relatively low value of 49 days has been chosen. Red sea urchins move very little after settlement (less than 10 m).

Growth and mortality rates have been estimated from size distributions collected along the coast of northern California (Morgan, et al. 2000).

California halibut (*Paralichthys californicus*)

The estimate of home range size is based on a tag-recapture study by Domeier & Chun (1995). Based on computer simulations, the mean home range diameter is estimated to be 70% of the mean recapture distance.

California halibut is a soft-bottom species. Although some individuals recruit into estuaries, more recent information suggests that recruitment also occurs along the open coast, consistent with the assumptions of the ROMS larval dispersal modeling.

Table B3-1. Kelp bass (*Paralabrax clathratus*)

Parameter	Value	Source
Pelagic larval duration	30 d	Cordes & Allen 1997
Spawning season	May-Sept	Oda et al 1993
Biogeographic assemblage	Southern / San Diegan	Allen et al. 2006
Range limit	not north of Point Conception or at San Miguel	CRANE data, Allen et al. 2006
Home range diameter	65 m	Lowe et al 2003
Length-at-age (cm TL)		
von Bertalanffy equation:		
$L(t) = L_{\infty}(1 - \exp(-k(t - t_0)))$		Love et al 1996
L_{∞}	69.8	
k	0.06	
t_0	-3.5	
Weight-at-length (cm, kg)		
$W = áL^{â}$		Young 1963
$á$	5.06 x10^{-6}	
$â$	3.27	
Maximum age	34 yr	Leet 2001
Age at maturity	3 yr	Love et al 1996
Natural mortality rate	0.29	Young 1967
Available to fishery	6 yr	CDFG Regulations

Table B3-2. Ocean Whitefish (*Caulolatilus princeps*)

Parameter	Value	Source
Pelagic larval duration	45 d	L. Bellquist, pers. comm.
Spawning season	Nov-March	Elorduy-Garay & Ramirez-Luna 1994, Dooley 1978
Biogeographic assemblage	Southern / San Diegan	Allen et al. 2006
Range limit	none	CRANE data, Allen et al. 2006
Home range diameter	161 m	Bellquist et al 2008
Length-at-age (cm TL)		
von Bertalanffy equation:		
$L(t) = L_\infty(1 - \exp(-k(t - t_0)))$		Cooksey 1980
L_∞	77.29	
k	0.23	
t_0	-0.016	
Weight-at-length (cm, kg)		
$W = \acute{a}L^{\hat{a}}$		Cooksey 1980
$\acute{a}$	2.83 x10^{-6}	
$\hat{a}$	3.15	
Maximum age	13 yr	Love 1996
Age at maturity	3 yr	Cooksey 1980
Natural mortality rate	0.17	Elouardy-Garay 2005
Available to fishery	2 yr	DFG Marine Status report 2003*, Cooksey 1980

* www.dfg.ca.gov/marine/status/report2003/oceanwhitefish.pdf

Table B3-3. Black perch (*Embiotoca jacksoni*)

Parameter	Value	Source
Pelagic larval duration	0	Love 1996
Spawning season	March-May	Schmitt & Holbrook 1984, Isaacson & Isaacson 1966
Biogeographic assemblage	Cosmopolitan in CA	Allen et al. 2006
Range limit	none	CRANE data, Allen et al. 2006
Home range diameter	50 m	Hixon 1979, Hixon 1981
Length-at-age (cm SL)		
von Bertalanffy equation:		
$L(t) = L_\infty\left(1 - \exp\left(-k\left(t - t_0\right)\right)\right)$		Froeschke et al 2007
L_∞	21.79	
k	0.3562	
t_0	-1.648	
Weight-at-length (cm, kg)		
$W = áL^{â}$		Froeschke et al 2007
$á$	1.16×10^{-4}	
$â$	2.8636	
Maximum age	9 yr	Love 1996
Age at maturity	1 yr	Love 1996, Froeschke et al 2007
Natural mortality rate	0.23	Hixon (1979), Schmitt and Holbrook (1990)
Available to fishery	1	

Table B3-4. Kelp rockfish (*Sebastes atrovirens*)

Parameter	Value reported	Source
Pelagic larval duration	60 d	Standish et al 2008
Spawning season	March-June	Love et al 2002
Biogeographic assemblage	Northern / Oregonian	Allen et al. 2006
Range limit	none	CRANE data, Allen et al. 2006
Home range diameter	8 km	Miller & Geibel 1973, Lea et al 1999, D. Hanan personal communication
Length-at-age (cm TL)		Lea et al. 1999, 2000, 2001
von Bertalanffy equation:		
$L(t) = L_{\infty}\left(1 - \exp\left(-k\left(t - t_0\right)\right)\right)$		
L_{∞}	378	
k	0.23	
t_0	-0.7	
Weight-at-length (cm TL, kg)		Lea et al 2002, 2003
$W = áL^{â}$		
$á$	9.37×10^{-6}	
$â$	3.172	
Maximum age	25 yr	Love et al 2002
Age at maturity	4 yr	Love et al 2002
Natural mortality rate	0.2	Estimated from lifespan
Available to fishery	4	L. Allen and M. McCrae, pers. comm.

Table B3-5. Opaleye (*Girella nigricans*)

Parameter	Value reported	Source
Pelagic larval duration	90 d	Waples 1987
Spawning season	May-July	Love 1996
Biogeographic assemblage	Southern / San Diegan	Allen et al. 2006
Range limit	none	CRANE data, Allen et al. 2006
Home range diameter	< 1 km	
Length-at-age (cm TL)		
von Bertalanffy equation:		
$L(t) = L_\infty(1 - \exp(-k(t - t_0)))$		Bredvik 2008
L_∞	28.36	
k	0.536	
t_0	-0.099	
Weight-at-length (cm TL, kg)		
$W = áL^{â}$		Bredvik 2008
$á$	4.0×10^{-5}	
$â$	2.95	
Maximum age	10 yr	Bredvik 2008
Age at maturity	4 yr	Bredvik 2008
Natural mortality rate	0.2	Estimated from lifespan
Available to fishery	2	L. Allen and M. McCrae, pers. comm.

Table B3-6. Sheephead (*Semicossyphus pulcher*)

Parameter	Value reported	Source
Pelagic larval duration	40 d	Waples 1987
Spawning season	May-July	Cowen 1985, DeMartini et al. 1994
Biogeographic assemblage	Southern / San Diegan	Allen et al. 2006
Range limit	not north of Point Conception	CRANE data, Allen et al. 2006
Home range diameter	139 m	Topping et al. 2005, 2006
Length-at-age (cm TL)		
von Bertalanffy equation:		
$L(t) = L_\infty\left(1 - \exp\left(-k\left(t - t_0\right)\right)\right)$		Alonzo et al. 2004
L_∞	83.86	
k	0.068	
t_0	0	
Weight-at-length (cm TL, kg)		
$W = \acute{a}L^{\hat{a}}$		Alonzo et al. 2004
$\acute{a}$	2.69×10^{-5}	
$\hat{a}$	2.857	
Maximum age	30 yr	Warner 1975, Alonzo et al. 2004
Age at maturity	4 yr	Warner 1975, Alonzo et al. 2004
Natural mortality rate	0.25	Estimated from Warner 1975, Cowen 1990
Available to fishery	7	CDFG Regulations

Table B3-7. Red Sea Urchin (*Strongylocentrotus franciscanus*)

Parameter	Value reported	Source
Pelagic larval duration	49 d	Leet 2001
Spawning season	Dec-March	Rogers-Bennett et al. 1995
Biogeographic assemblage	Cosmopolitan in CA	Leet 2001
Range limit	none	CRANE data, Allen et al. 2006
Home range diameter	0.01	
Length-at-age (test diameter, cm)		
von Bertalanffy equation:		
$L(t) = L_\infty(1 - \exp(-k(t - t_0)))$		Values reported in Kaplan et al. 2006
L_∞	11	
k	0.22	
t_0	0	
Weight-at-length (cm, kg)		
$W = áL^{â}$		Values reported in Smith and Wilen 2003
$á$	6.76×10^{-4}	
$â$	2.68	
Maximum age	50 yr	Values reported in Kaplan et al. 2006
Age at maturity	4 yr	Values reported in Smith and Wilen 2003
Natural mortality rate	0.08	Values reported in Kaplan et al. 2006
Available to fishery	8	CDFG Regulations

Table B3-8. California halibut (*Paralichthys californicus*)

Parameter	Value reported	Source
Pelagic larval duration	25 d	Kucas and Hassler 1986, Moser and Watson 1990, Leet 2001, Love 1996
Spawning season	Year-round, peaks in Feb, July, Oct	Moser and Watson 1990
Biogeographic assemblage	Cosmopolitan in CA	Allen et al. 2006
Range limit	none	CRANE data, Allen et al. 2006
Home range diameter	9 km	Domeier and Chun 1995
Length-at-age (cm TL)		MacNair et al 2001
von Bertalanffy equation:		
$L(t) = L_\infty\left(1-\exp\left(-k\left(t-t_0\right)\right)\right)$		
L_∞	136.77	
k	0.08	
t_0	-1.2	
Weight-at-length (cm TL, g)		Reed and MacCall 1988
$W = áL^{â}$		
á	8.70×10^{-6}	
â	3.0496	
Maximum age	30 yr	Love 1996
Age at maturity	4 yr	Love and Brooks 1990
Natural mortality rate	0.15	Reed and MacCall 1988
Available to fishery	5	CDFG Regulations

B4. Examples of Bioeconomic Model Output to Be Used as Feedback on Individual MPA Performance

The following figures are examples of model outputs that will be provided to help improve alternative MPA proposals. These example results were produced by the UCSB model based on a proposal of three MPAs: MPA A - near San Diego, MPA B - near Santa Barbara and MPA C – at San Nicolas Island.

Figure B4-1. Conservation Value (Biomass as a Fraction of Unfished Biomass) for All Regions and for Each Subregion Separately

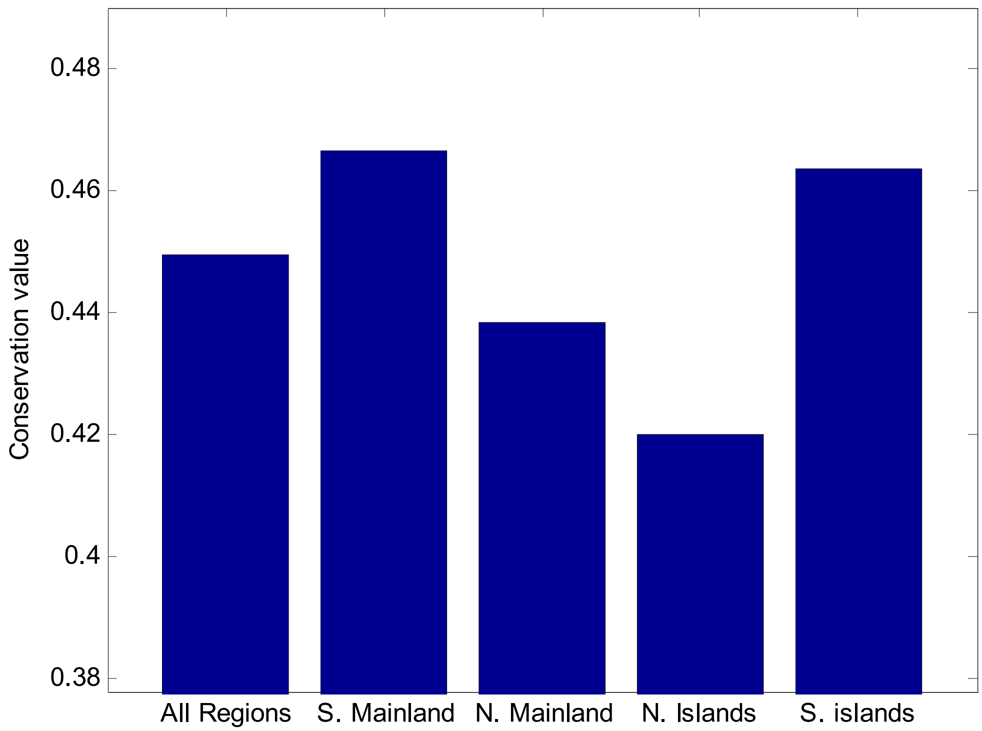


Figure B4-2. Economic Value (Profit with Reserves as a Fraction of Maximum Sustainable Profit without Reserves) for All Regions and for Each Subregion Separately.

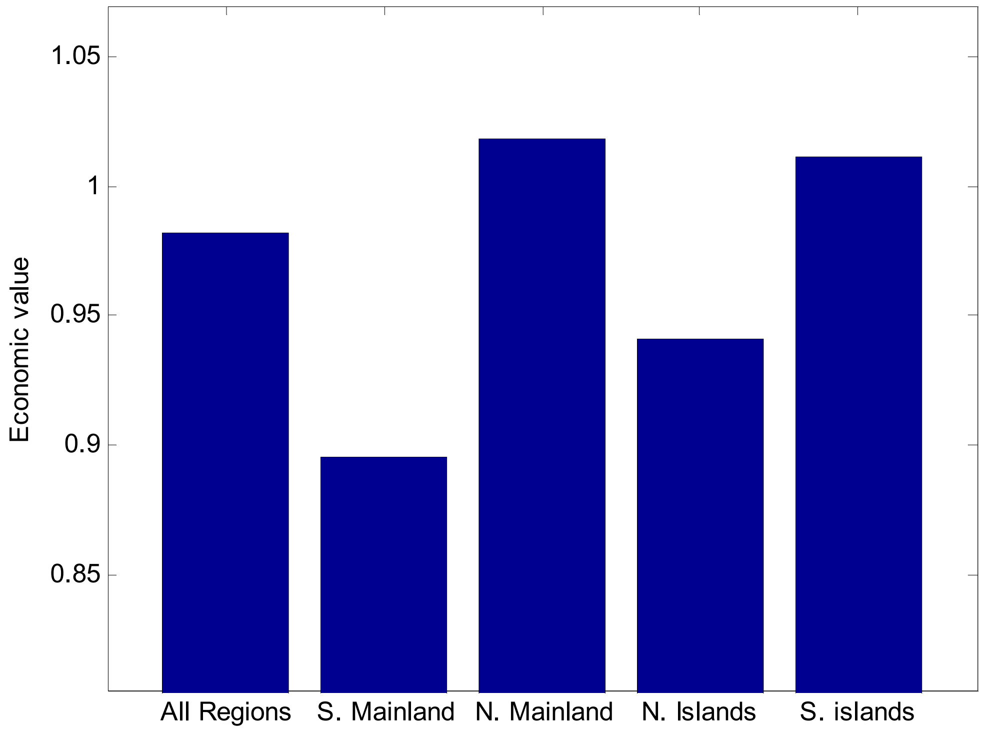


Figure B4-3. The Mass of Fish in Each Reserve, as a Fraction of the Total Mass of Fish in the Whole System

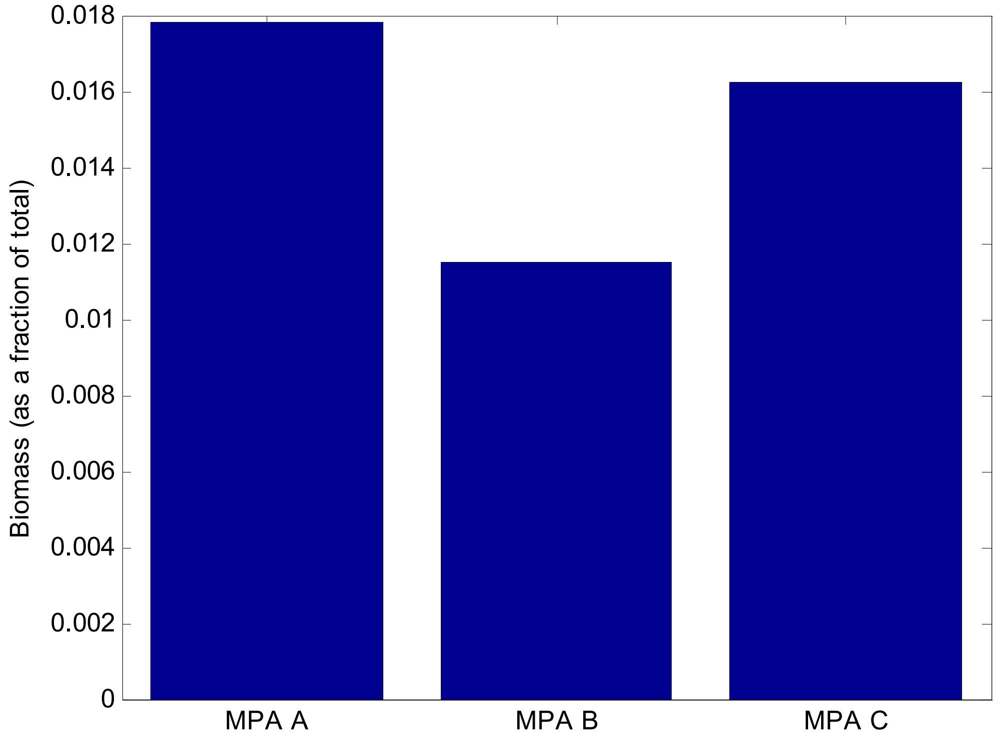


Figure B4-4. The Fraction of Larvae Arriving in Each Reserve which were Produced within the Reserve

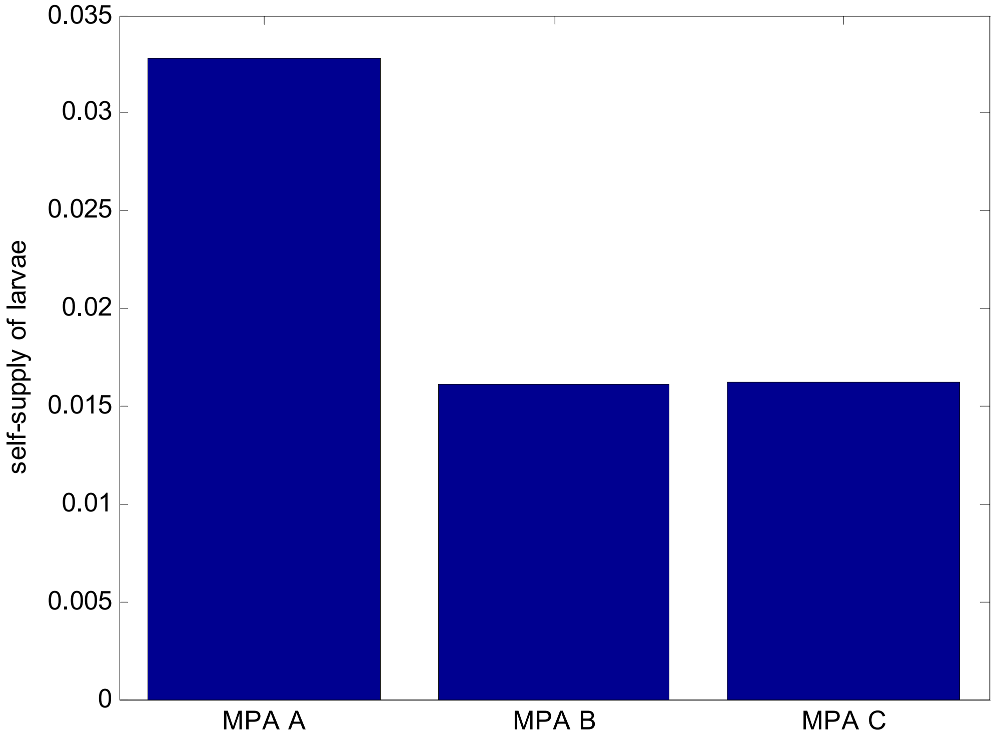


Figure B4-5. Conservation Value for the Whole System, for Subsets, and for No MPAs

Conservation Value (Biomass as a Fraction of Unfished Biomass) for the Whole System with All Reserves (i.e. the Whole MPA Proposal), as well as with All Reserves Except Reserve A, All Except Reserve B, All Except Reserve C and No MPAs

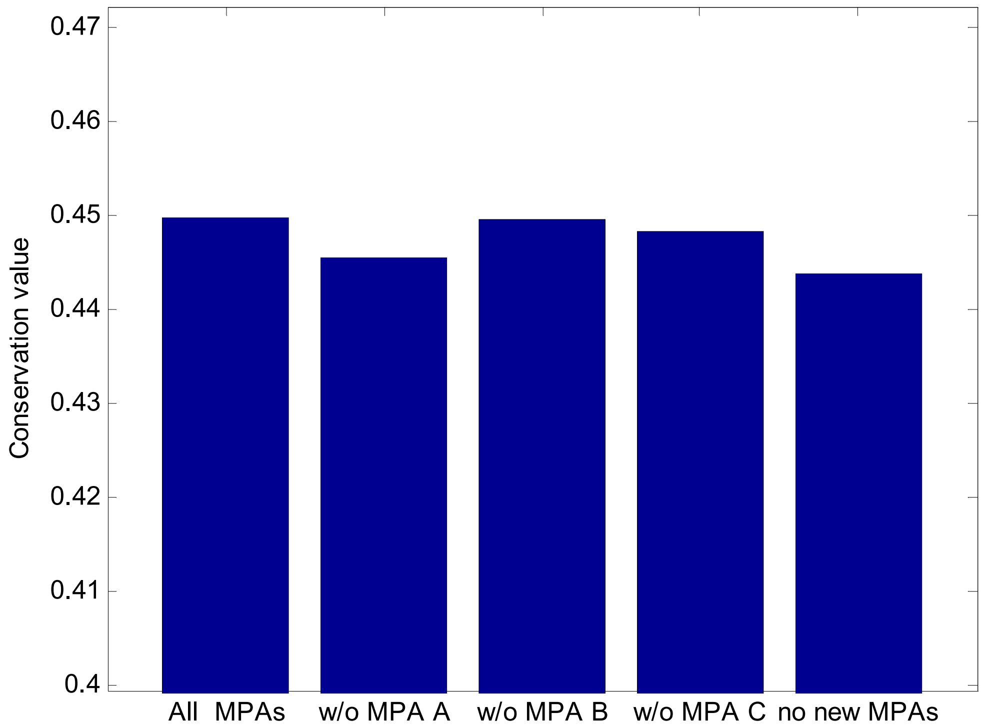
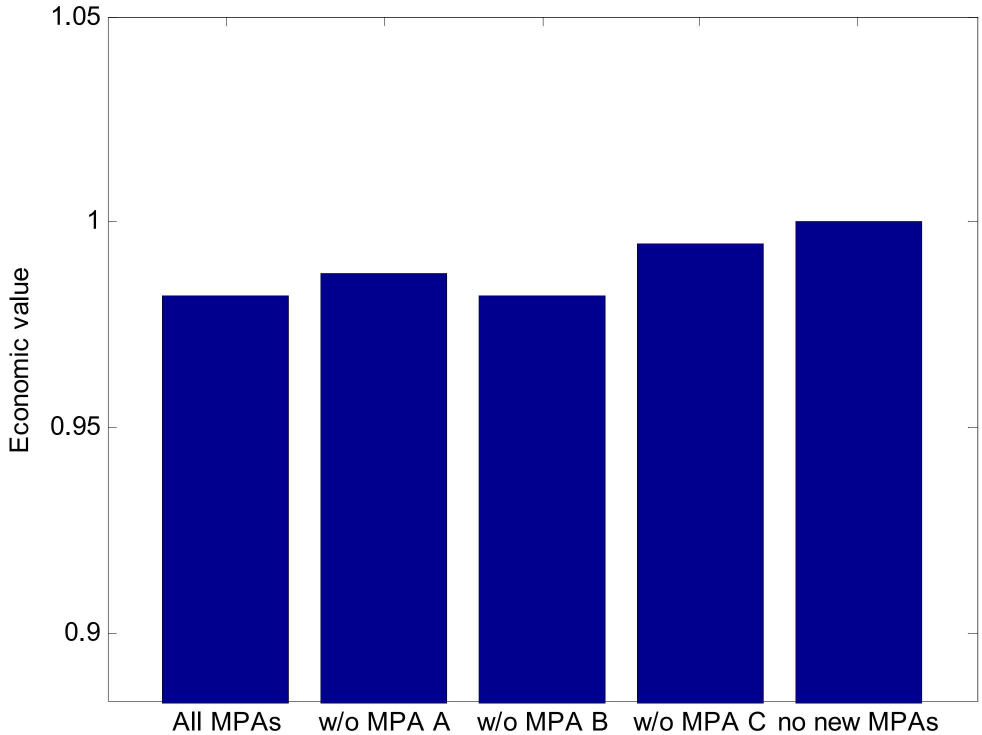


Figure B4-6. Economic Value for the Whole System, for Subsets, and for No MPAs

Economic Value (Profit with Reserves as a Fraction Maximum Sustainable Profit Without Reserves) for the Whole System with All Reserves (i.e. the Whole MPA Proposal), as well as with All Reserves Except Reserve A, All Except Reserve B, All Except Reserve C and No MPAs



Appendix C. Socioeconomic Impact Assessment Methods

The primary goal of this analysis is to estimate the socioeconomic impact to the commercial fishery sector associated with each of the MPA proposals. To accomplish this, staff from Ecotrust, contractor to the MLPA Initiative, will estimate the maximum potential economic impact for each of the MPA proposals using methods developed in the Central Coast process (see Wilen and Abbott, 2006). This analysis assumes that each of the MPA proposals completely eliminate fishing opportunities in areas closed to specific fisheries and that fishermen are unable to adjust or mitigate in any way (Wilen and Abbott, 2006). The results can then be considered by each group (i.e. stakeholders, SAT, BRTF, Initiative staff, FGC) as trade-offs for protections relative to socioeconomic impacts can be weighed in siting and evaluating MPA proposals. The remainder of this paper describes the steps needed to complete the maximum potential economic impact analysis, as the process is used in the South Coast Study Region.

1: Generate Baseline Estimates of Gross Economic Revenue

The first step involves calculating a baseline estimate from which to derive estimates of the socioeconomic impact associated with changes in commercial fisheries that might be induced by each MPA alternative and against which to compare those estimates. The baseline estimate is generated using gross fishing revenues from regional landing receipts. A seven-year average, 2000-2007 derived from the California Department of Fish and Game (DFG) landing receipts reported for ports in the South Coast Study Region is used, and then these values are converted into current dollar values (i.e. $2007).

More specifically, to generate baseline estimates of gross economic revenue (GER), for any fishery, *f*, $BGER_f$ is the average ex-vessel value of the fishery in 2007 dollars, where

$BGER_f = \sum_{p \in P} BGER(f, p)$, the sum of the baseline estimates of GER for this fishery over all ports.

Staff also define the fisheries specific to each port, or in other words, create a baseline estimate of gross economic revenue for each port. For a specific port, *p*, being considered in the South Coast Study Region the baseline estimate ($BGER_p$) can be calculated as the sum of the baseline estimates of GER for this port over all fisheries:

$$BGER_p = \sum_{f \in F} BGER(f, p).$$

The baseline gross economic revenue ($BGER_{TOT}$) for <u>all</u> commercial fisheries ($f \in F$) being considered in the South Coast Study Region is therefore

$BGER_{TOT} = \sum_{f \in F} BGER_f = \sum_{f \in F} \sum_{p \in P} BGER(f, p)$ or equivalently,
$BGER_{TOT} = \sum_{p \in P} BGER_p = \sum_{p \in P} \sum_{f \in F} BGER(f, p)$.

2: Generate Gross Economic Revenue for the Various MPA Alternatives

The next step involves using results from the Ecotrust mapping exercise, specifically stated importance indices from the fishing grounds, to estimate the socioeconomic impact associated with changes in the commercial fisheries that might be induced by each MPA alternative. For a description of the methods used to create stated importance indices, please see Scholz et al. (2006).

For any fishery, *f*, port, *p*, and any MPA alternative, *a*:

$$GER(f, p, a) = BGER(f, p) - GEI(f, p, a)$$

where $GEI(f, p, a)$ is the estimated gross economic impact on fishery, *f*, at any port, *p*, under any alternative, *a*.

Therefore,

$$GER_f(a) = \sum_{p \in P} GER(f, p, a) \text{ and } GER_p(a) = \sum_{f \in F} GER(f, p, a)$$

as well as

$$GEI_f(a) = \sum_{p \in P} GEI(f, p, a) \text{ and } GEI_p(a) = \sum_{f \in F} GEI(f, p, a).$$

Gross economic revenue under any alternative, *a*, ($GER_{TOT}(a)$), for <u>all</u> commercial fisheries ($f \in F$) being considered in the South Coast Study Region can be calculated as:

$$GER_{TOT}(a) = \sum_{f \in F} GER_f(a) = \sum_{p \in P} GER_p(a) = \sum_{f \in F} \sum_{p \in P} GER(f, p, a) = \sum_{p \in P} \sum_{f \in F} GER(f, p, a)$$

From this it can be said that, for any MPA alternative, *a*,

$$GEI_{TOT}(a) = BGER_{TOT} - GER_{TOT}(a)$$

where GEI_{TOT_a} is defined as the total gross economic impact on all commercial fisheries under any alternative, *a*. Therefore,

$$GEI_{TOT}(a) = \sum_{f \in F} GEI_f(a) = \sum_{p \in P} GEI_p(a) = \sum_{f \in F} \sum_{p \in P} GEI(f, p, a) = \sum_{p \in P} \sum_{f \in F} GEI(f, p, a).$$

3: Generate Baseline Estimates of Net Economic Revenue

In order to compute net economic benefits, staff 1) estimate the share of gross fishing revenues represented by costs, and 2) scale the baseline estimate (i.e. gross fishing revenues) calculated in Step 1 using the estimated cost shares. In the Central Coast process, an estimate of 65% was used across all fisheries (Wilen and Abbott, 2006). For the South Coast process, several cost related questions are asked during interviews with fishermen in an effort to improve on this estimate as well as allow for the ability to account for cost variability between different fisheries in this analysis. After all interviews are completed, the cost data are broken out by fishery or fisheries. For example, cost data for a fisherman who fished both salmon and crab would be aggregated with only other interviewees participating in both those fisheries. A mean or median cost estimate is then calculated for each category.

Costs will be broken into two categories: fixed costs and variable costs. Fixed costs include costs that are independent of the number of trips a vessel makes or the duration of these trips. For example, vessel repairs and maintenance, insurance, mooring and dockage fees typically considered fixed costs. On the other hand, variable costs include costs that are dependent on the number of trips a vessel makes of the duration of these trips. Variable costs typically include fuel, maintenance, crew share, gear repair/replacement. For the purpose of this study, variable costs are assumed to be crew wages and fuel costs. All other costs will be considered fixed costs.

For any fishery, *f*, net economic revenue is calculated as:

$$BNER_f = BGER_f - C_{X_f} - C_{V_f}$$

where C_{X_f} is the fixed cost associated with any fishery, *f*, and is set as a fixed dollar value, and C_{V_f} is the variable cost associated with any fishery , *f*, and is a fixed percentage of $BGER_f$.

Baseline net economic revenue ($BNER$) for <u>all</u> commercial fisheries ($f \in F$) being considered in the South Coast Study Region can be calculated as:

$$BNER_{TOT} = \sum_{f \in F} BNER_f$$

4: Generate Estimates of Net Economic Revenue for the Various MPA Alternatives

In order to compute net economic revenue for each of the various MPA alternatives, staff analysis 1) estimates the share of gross fishing revenues represented by costs under each MPA alternative, and 2) scales the estimated gross fishing revenues for that alternative accordingly. Costs will be calculated using the methods described in Step 3.

For any fishery, *f*, and any MPA proposal, *a*,

$$NER_f(a) = GER_f(a) - C_{X_f} - C_{V_f} \ .$$

For any MPA alternative, *a*, net economic revenue for <u>all</u> commercial fisheries ($NER_{TOT}(a)$) can be calculated as:

$$NER_{TOT}(a) = \sum_{f \in F} NER_f(a)$$

5: Generate Estimate of the Potential Primary Economic Impact for the Various MPA Alternatives

Using the results from the previous steps, the potential primary net economic impact (NEI) of a particular MPA alternative, *a,* on a particular fishery, *f,* can then be calculated as:

$$NEI_f(a) = BNER_f - NER_f(a).$$

The potential primary NEI of any MPA alternative, *a,* on <u>all</u> commercial fisheries ($f \in F$) can then be calculated as:

$$NEI_{TOT}(a) = BNER_{TOT} - NER_{TOT}(a).$$

Example of Estimate Costs

For fishery *f*, assume the following proportion of gross economic revenue goes to the following costs:

- 20% = fixed costs
- 20% = crew wages
- 10% = fuel costs → 30% = variable costs

Assume that baseline gross economic revenue equals $10,000.00. Under the baseline, fixed costs equal $2,000 and variable costs equal $3,000, resulting in total costs of $5,000. Assume that under MPA alternative *a,* gross economic revenue now equals $5,000. Under this alternative, fixed costs will still equal $2,000; however, variable costs will be recalculated as:

$5,000 * 0.3 = $1,500

This results in total costs of $3,500 under MPA alternative *a.*

References for Appendix C

- Scholz, Astrid, Charles Steinback and M. Mertens. 2006. Commercial fishing grounds and their relative importance off the Central Coast of California. Report submitted to the California Marine Life Protection Act Initiative. May 4, 2006.
- Wilen, James and Joshua Abbott, “Estimates of the Maximum Potential Economic Impacts of Marine Protected Area Networks in the Central California Coast,” final report submitted to the California MLPA Initiative in partial fulfillment of Contract #2006-0014M (July 17, 2006)